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This booklet was developed to provide helpful suggestions for planetarium directors, teachers, and school supervisors. The booklet is divided into seven different units of study. Each unit is similar in design and format, beginning with an overview of the topic followed by a description of planetarium activities which the authors successfully employed in their classes during the 1963-64 school year. Each unit also includes related vocabulary, suggested questions and activities for pupils, mention of pioneers in science, and lists of selected books and audiovisual aids. A brief description of the Bridgeport Planetarium is included in order to give the potential user a better appreciation of possibilities in his own locale. Teachers who do not have ready access to planetariums may also find this booklet useful for its suggestions relative to resources and activities. (BC)

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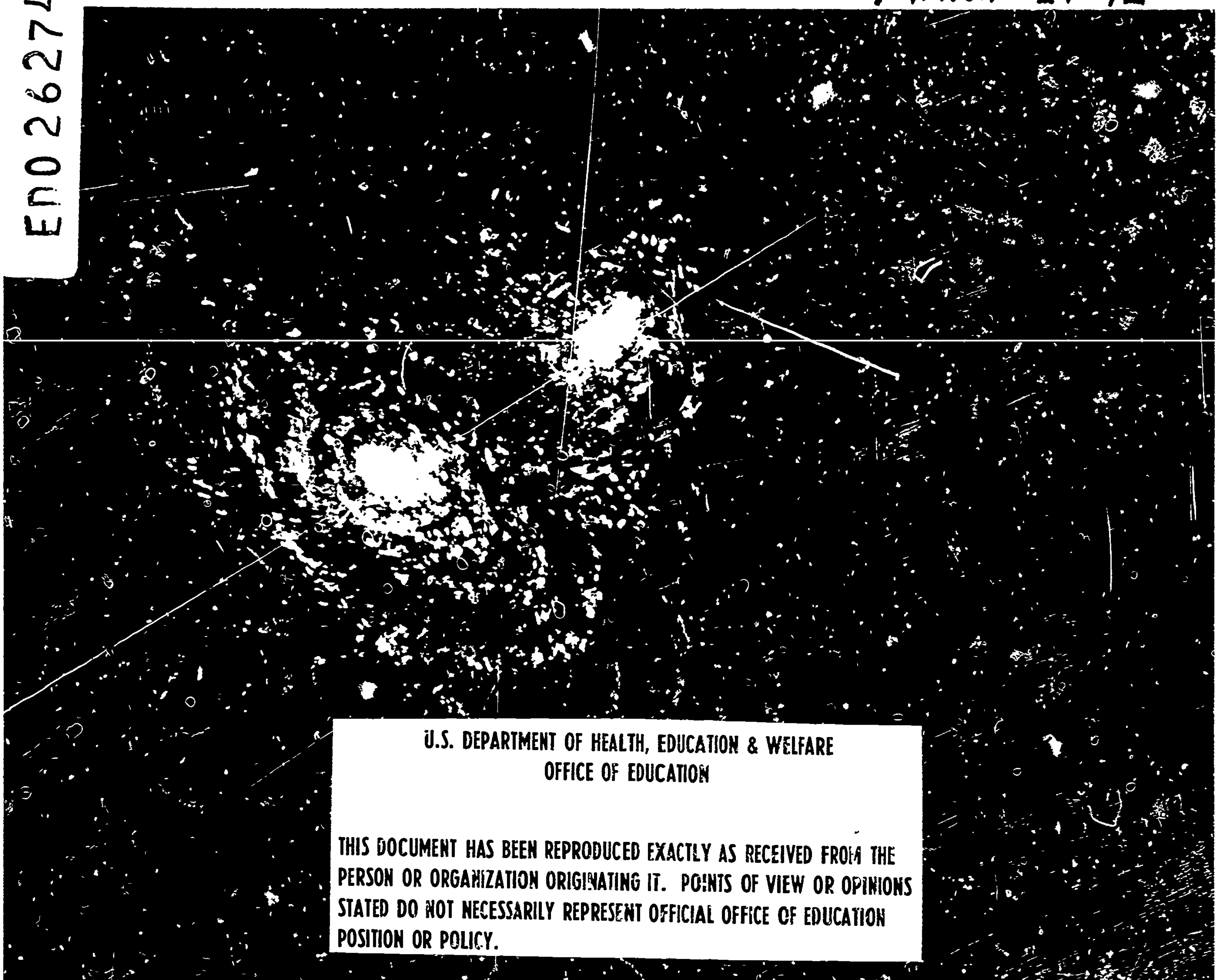

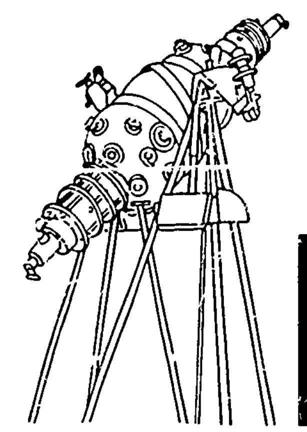

THE PLANETARIUM

An Elementary-School Teaching Resource

Prepared by the University of Bridgeport for
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The Planetarium

An Elementary-School Teaching Resource

A report to the Office of Public Affairs, Educational Programs Division, National Aeronautics and Space Administration, of a space science instructional materials project of the University of Bridgeport and the Planetarium of the Museum of Art, Science, and Industry, Bridgeport, Connecticut, conducted at the planetarium during the school year, 1963-64.

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Frances Humphreville, Supervisor of Intermediate and Upper Elementary Grades, Bridgeport Public Schools

David M. Silverstone, Director of Audio-Visual Education, University of Bridgeport

Phillip D. Stern, President, Planetariums Unlimited, and former Director of the Planetarium of the Museum of Art, Science, and Industry, Bridgeport, Connecticut

Editor:

Bartlett A. Wagner, Elementary Education Science Specialist, University of Bridgeport

Prepared by the University of Bridgeport for
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
February 1966

FOREWORD

For almost a decade, elementary-school teachers have been aware of the interest of children in the efforts to explore space. Teachers have sensed the excitement of their youngsters in the Ranger and Surveyor moon pictures and the Mariner Venus and Mars probes, the Mercury and Gemini flights, and the weather and communications satellites. They have watched the names of Glenn, Grissom, Cooper, Schirra, Stafford, Young, White, McDivitt, and other space explorers become part of the children's heritage. Teachers recognize the many possibilities for stimulating children's learning in the humanities and fine arts as well as in science and mathematics.

Recognizing the interest of elementary schools in space exploration, the University of Bridgeport and the Planetarium of the Museum of Art, Science, and Industry, with the encouragement and support of the National Aeronautics and Space Administration, undertook a joint project to explore and develop planetarium offerings that would help enrich the elementary-school curriculums of neighboring communities. A committee, headed by Phillip D. Stern, who was Planetarium Director at the time, was formed. This committee included selected educators from the Metropolitan Bridgeport area. Problems were identified and classroom programs were developed during 1963-1964.

The committee met regularly to revise and refine the programs. The procedures and instructional materials were utilized in classroom situations and at the Bridgeport Planetarium. This publication, a report to the National Aeronautics and Space Administration, calls attention to areas of classroom and planetarium interest as well as activities, publications, and audio-visual materials that were compiled and selected by the committee. The review committee, which has met regularly since the original program was developed, has kept bibliographical and audio-visual listings up to date.

The University recognizes that planetariums differ from one another in many respects. It is also aware that planetariums effect many changes in their programs and offerings from time to time.* It is hoped that this report of activities conducted in cooperation with the Bridgeport Planetarium by Bridgeport area teachers in 1963-64 may provide some helpful suggestions for planetarium directors, teachers, and school supervisors and administrators in other parts of the nation.**

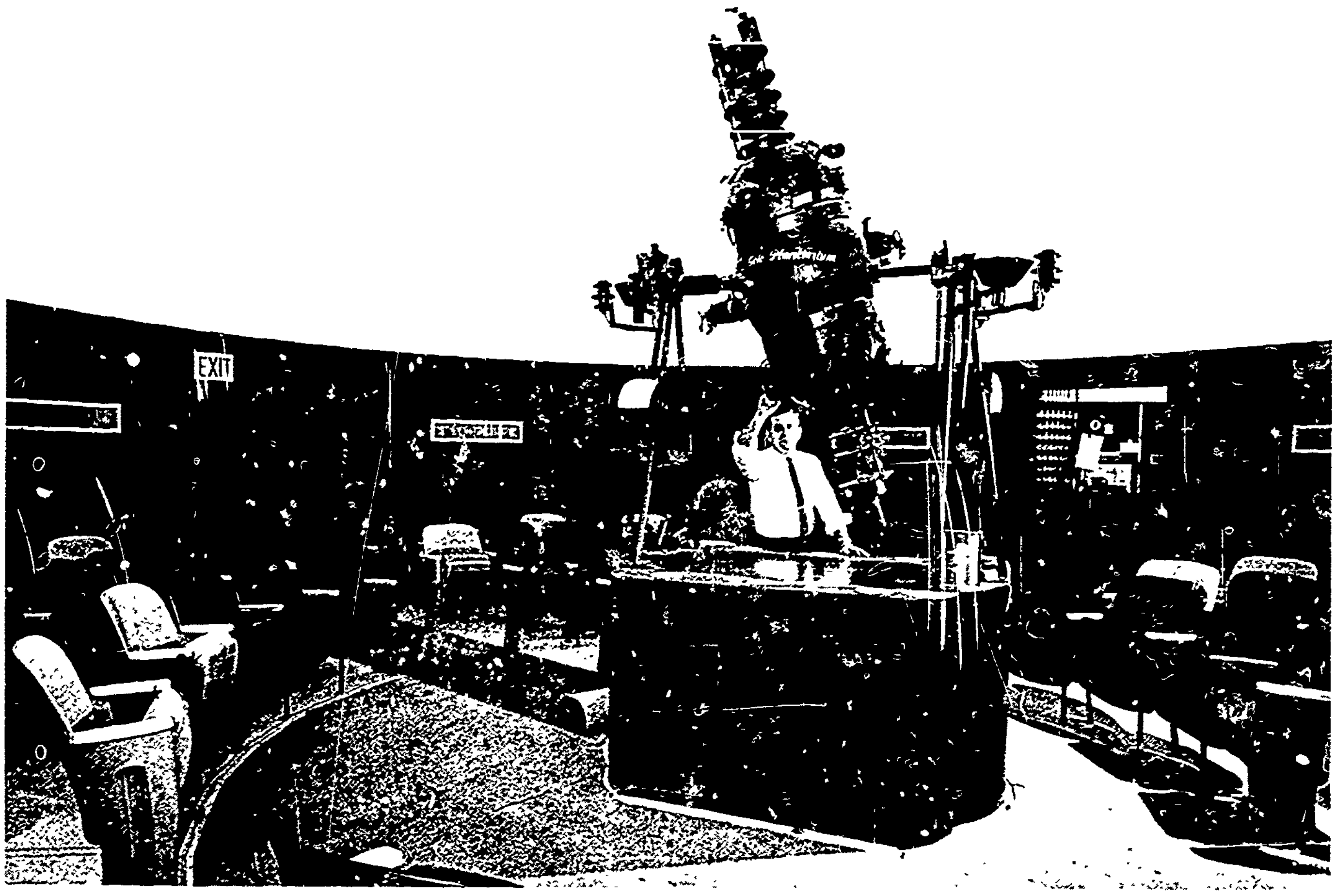
Elementary-school teachers may find clues for relating areas under study to a planetarium visit. Administrators and supervisors may find implications for curriculum development. Planetarium directors may find suggestions that would influence planetarium offerings. A brief description of the Bridgeport Planetarium is included in order to give the reader a better appreciation for possibilities in his own locale. Although this publication tells what use elementary school teachers may make of planetariums, each section, or chapter, is so organized and so rich in suggested resources and activities that it will also be found useful by teachers who do not have ready access to a planetarium.

The booklet is divided into seven different units of study. Each unit is similar in design and format. The units begin with an overview of the topic under study, followed by a description of planetarium activities which the committee members and their classes experienced during the school year 1963-64. Each unit also includes related vocabulary, suggested questions and activities for pupils, science pioneers, and selected books and audio-visual aids.

**The programs of the Bridgeport Planetarium as noted on the following pages have undergone modification and change since 1964.*

***A list of the nation's planetariums is being compiled by NASA.*

THE BRIDGEPORT PLANETARIUM



Planetarium projector at the Bridgeport Planetarium

The Bridgeport Planetarium is part of the Museum of Art, Science, and Industry, Bridgeport, Connecticut. The Museum now contains eight galleries, a lecture hall, two classrooms, and the Planetarium on its three floors.

The Planetarium is hemispheric in shape and seats approximately 125 people. Sections of seats are moveable to allow for wheel chair occupants. The diameter of the room is 33 feet and the distance from the projector to the ceiling is 16 feet. The Goto Planetarium Projector, model M-1, offers lens projection and motorized diurnal, annual, precession, and latitude change.

Special effects are produced by audio tape recordings and a cove of 35 mm. slide projectors. Approximately 20 slide projectors are situated to produce peripheral scenes on the hemispheric wall. Tape recordings of musical selections and sound effects, activated by the speaker, accompany visual effects such as sunrise and sunset. Speakers are located around the room to increase audio fidelity. The speaker operates the Goto Planetarium Projector, the cove of slide projectors, and the audio tape recordings from an electronically equipped console.

ACKNOWLEDGEMENTS

For generous and wholehearted cooperation, we express our appreciation to the Bridgeport Museum of Art, Science, and Industry, its Board of Directors, and its management. Special acknowledgement and thanks is given to Phillip D. Stern, former Director of the Planetarium, for his dynamic and imaginative leadership during the course of the project. We also wish to thank the members of the project committee, whose names appear on a separate page, and their school authorities who encouraged their participation.

Singled out for special recognition and thanks for assistance in the final review and editing are Phillip D. Stern; Frances Humphreville, Supervisor of Intermediate and Upper Elementary Grades, Bridgeport Public Schools; and David M. Silverstone, Director of Audio-Visual Education, University of Bridgeport. Also, for the exacting task of editing this final report, we wish to thank Bartlett A. Wagner, Elementary Education Science Specialist, University of Bridgeport.

To our colleagues in the University's administration and faculty, whose interest and efforts fostered this project, we are grateful to Henry W. Littlefield, President; Albert E. Diem, Vice-President; Owen C. Geer, Professor of Education, who served as one of the project consultants, editors, and resource compilers; David M. Silverstone, Director of Audio-Visual Education, who served as audio-visual compiler and member of the review committee; and to Geoffrey S. Skrog, art education student, who assisted with the art work. We also thank Kenneth M. McIntyre, Director, Bureau of Audio-Visual Education, University of North Carolina; and O. W. Kopp, Chairman, Department of Elementary Education, The Teachers College, University of Nebraska, for their prompt and helpful reaction to requests for audio-visual and bibliographic listings.

We note and appreciate the services of Dorsey Baynham, of Washington, D.C., editorial consultant, and Donald Clarkson, University of Bridgeport, who assisted in the final preparation of the report, and of Frank Gerratano, Bridgeport photographer, for providing service and photographs.

Finally, we express gratitude to the National Aeronautics and Space Administration and its staff members of the Educational Programs Division.

Harold W. See, Dean
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January 1966

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I. THE PLANETARIUM TEACHES ABOUT THE HISTORY OF SCIENCE

Man first expressed an interest in science when he asked himself why certain things happened. Since the first man to ask this question lived thousands of years ago he had to rely on his imagination for answers. He invented gods and myths to explain why things happened as they did.

Today we explain things differently in science. Our explanations are characterized by careful examination of all available evidence, precise measurement of whatever variables can be measured, and careful construction of the resulting interpretations or conclusions. Each conclusion serves as a foundation for prediction of future occurrences, but is also regarded as tentative and subject to review in the light of new evidence. Thus, science may be thought of as cumulative knowledge which improves with the examination of new evidence.

Aristotle, in the fourth century, B.C., was among the first to recognize the importance of "method" in science. He set up scientific procedures which included (1) collecting observations of natural phenomena, (2) organizing the observations in an orderly fashion, and (3) identifying a principle or conclusion which summarized the observations. But Aristotle's conclusions in astronomy were based on how things *appeared* to behave. This, coupled with the Greeks' enthusiasm for deductive logic, led to several "self-evident" axioms that the earth was motionless and was at the center of the universe, and that the speed of an object's fall was proportional to its weight. The potential of Aristotle's method was not realized until the Renaissance.

The astronomer Copernicus, about 1512, dared to propose the theory that the earth revolved around the sun. Tycho Brahe, a Danish astronomer of the same period and the first astronomical observer of modern times, was unable to accept fully the revolutionary Copernican theory but fell back somewhere between it and the old idea that the earth was the center of the universe. It was an assistant of Brahe, Johannes Kepler, who took the next big step toward ultimately establishing the Copernican Theory. Kepler formulated what have become known as Kepler's Laws of Planetary Motion, which include the statement that the planets revolve around the sun in elliptical paths.

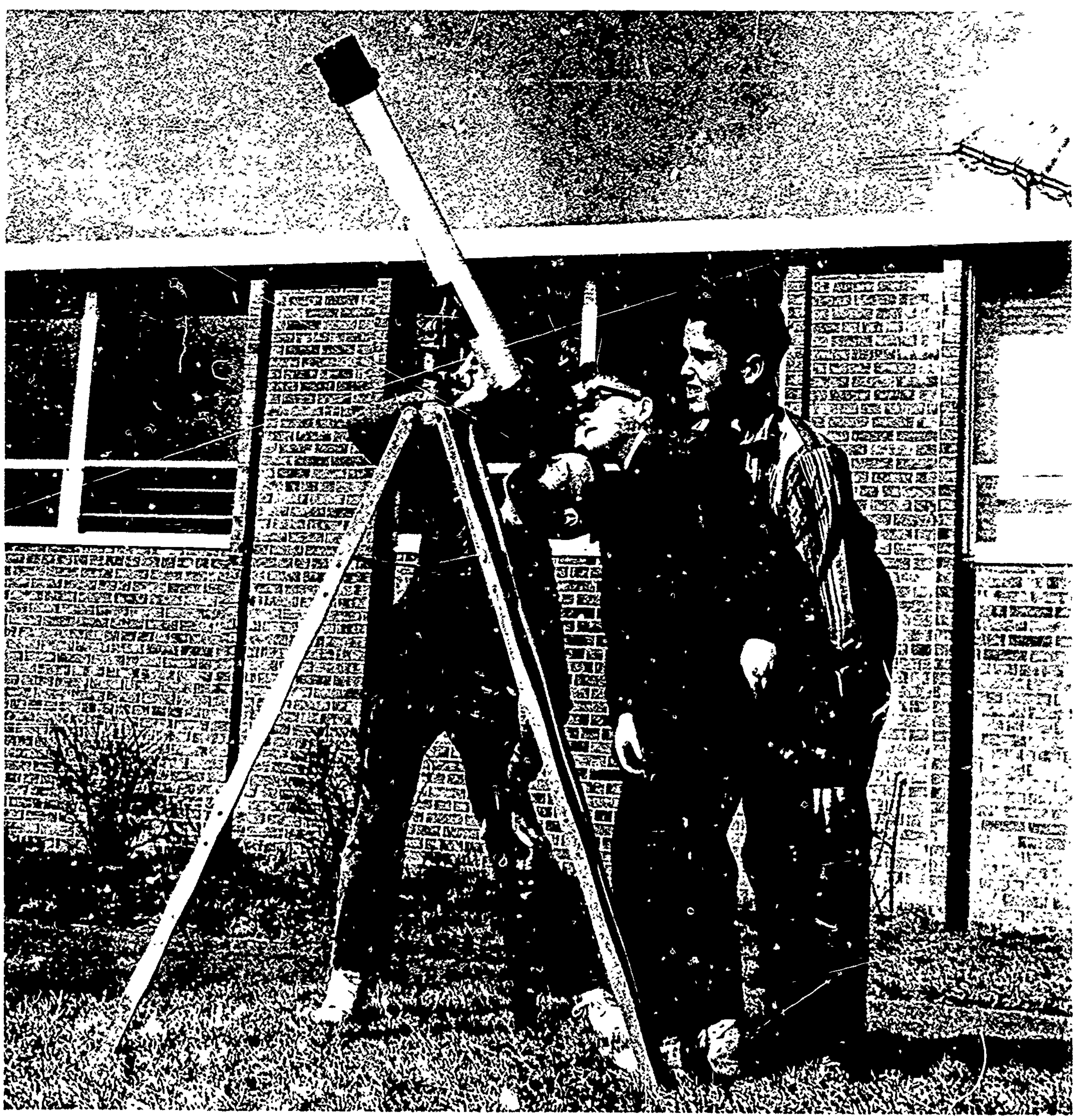
Galileo, the father of modern science, helped usher in an era of inductive thinking, in which conclusions were based upon observation rather than upon logical deductions. In his great *Dialogue of the Two Chief Systems of the World*, written in 1632 and based upon his telescopic observations, Galileo ably defended the Copernican theory of the revolving and rotating earth.

About the same time, Francis Bacon was working on a system to be called the Baconian Method for interpreting natural phenomena. The Baconian Method was essentially empirical, based upon three main steps: (1) description of the facts; (2) classification of the facts; (3) elimination of those facts not connected with the phenomena. While we today recognize this system as greatly oversimplified, it nevertheless served the important function of emphasizing careful observation, systematic record, and evaluation.

In the latter half of the 17th century, Sir Isaac Newton made his tremendous contributions to science. Public reaction toward those scientific theories which represented radical departures had begun to change. While earlier followers of scientific order often defied ridicule, disgrace, and even death to support their beliefs, Newton was all but deified in his own lifetime. Scientific method and the beginning of free and cooperative

communication among scientists had revealed entire new concepts about the nature of the universe.

As scientific investigation began to bear fruit, people began to look upon science as an unchanging body of facts. In the last few years, however, we have found that what were previously regarded as well established facts were really false conclusions; what were thought to be areas beyond the scope of man's ability to investigate have been penetrated. But, in spite of expanding knowledge and highly refined instruments of investigation, the nature of scientific inquiry remains essentially the same. The field of astronomy amply demonstrates this and the planetarium laboratory, perhaps more vividly than any other educational resource, affords a realization of the compelling demand for method and order in man's continuing quest for understanding of the universe.



THE BRIDGEPORT PLANETARIUM VISIT, 1963–64

A Brief Account of the Class Experience

The man-made blue sky, white clouds, and noonday sun of the planetarium aid in taking the pupils back thousands of years to a time when the sun was the most important of all gods. Our primitive ancestors worshipped the sun because it gave them light and food and kept them warm.

The lecturer explains that the young men of the primitive tribes spent most of their time hunting and fishing while the elders of the tribes stayed at home to tend the campfires and to observe the Sun God. It was the elders' special duty to interpret the Sun God's moods. If a cloud momentarily concealed his face, he was thought to be mildly displeased with his children, and if the sky were overcast he was thought to be greatly annoyed with their transgressions. If a thunder storm lit up the sky he was indeed angry. The people offered prayers and sacrifices and promised to mend their ways.

The lecturer then tells how the people sat around the campfires when the sun had set and the stars had appeared, while the story tellers among them pointed out the strange pictures in the sky and named the brightest stars. Sometimes the story tellers pointed out a "wandering god," a star that moved mysteriously among the thousands of other "fixed" stars. The Greeks called these wandering stars planets. When the moon, a benign goddess, trailed across the sky, the people prayed to her because she enabled man, by her light, to hunt and to harvest during the autumn, when food was gathered and stored for winter.

Then the planetarium scene changes to a city in the Euphrates Valley and the pupils get a close-up view of the parapets of a great temple, where priests and scribes painstakingly recorded details of their observations of the heavens on clay tablets. The tablets were then baked in the heat of the sun and these records were th[illegible] preserved for ages to come. The lecturer then tells of the Chaldeans' amazing discovery of the repetition of eclipses—data so accurate that today's instruments and methods can do little to improve it.

As time and the scene move forward to the age of the Greek philosophers and their schools, the pupils watch and listen as superstition gradually gives way to reason and men study the motions of the heavenly bodies to evolve a mathematical system that will predict the movements of the planets. Ptolemy's concept of a geocentric universe is described, with the sun, moon, planets, and stars revolving around the earth. Ptolemy believed that the planets turned on smaller circles called epicycles, which in turn moved around the earth in great circles known as deferents. Ptolemy's ideas were accepted as facts for about fourteen hundred years. It was not until Copernicus, Kepler, Galileo and others that new ideas and concepts were developed.

Planetarium demonstrations of this kind offer a "you-are-there" presentation. These demonstrations are designed to profile early scientists, their discoveries, and their research. By taking part in such presentations the pupils return to their classrooms, their books, their interests, and their ideas with new insights that make science come alive.

PIONEERS IN THE DEVELOPMENT OF SCIENCE

Archimedes	*(About 287–212 B.C.)*
Aristotle	*(384–322 B.C.)*
Averroes or (Ibn Rushd)	*(1126–1198 A.D.)*
Bacon	*(1561–1626 A.D.)*
Cavendish	*(1731–1810 A.D.)*
Copernicus	*(1473–1543 A.D.)*
Faraday	*(1791–1867 A.D.)*
Galileo	*(1564–1642 A.D.)*

Kepler *(1571–1630 A.D.)*	Newton *(1642–1727 A.D.)*
Maxwell *(1831–1879 A.D.)*	Pythagoras *(6th Century B.C.)*

VOCABULARY

axiom deductive logic elliptical orbit evidence inductive logic method
myth phenomenon planet prediction revolve rotate variable

SOME QUESTIONS CONCERNING THE HISTORY OF SCIENCE

1. What is meant by "method of science"?
2. Can we as individuals use the "method of science" to help solve personal problems?
3. Can the "method of science" be applied by citizens of a democracy to solve the political, economic, and diplomatic problems of city, state, or nation?
4. Why do some experts say that the 20th century may come to be regarded as the most important century in the history of astronomy?
5. What contribution did Aristotle make to the development of scientific knowledge?
6. What were some of the contributions of Copernicus, Kepler, Galileo? Were the discoveries of these scientists welcomed by the people of their times?
7. What were some of Newton's discoveries? How was Newton regarded by the people of his time?
8. What do scientists of today say about the nature of the moon's surface? What arguments do scientists use to support these theories?
9. What tool for obtaining information about the heavens did the astronomers have in Newton's time? What tools did they have 30 years ago? What tools are they developing now?
10. What important events in history were taking place during the times Aristotle, Copernicus, Galileo, and Newton lived?
11. Was there much activity in science between 500 A.D. and 1400 A.D.? What reasons have been given by historians for this?

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Look at distant objects through a telescope.
2. Tell the class stories about some of the major constellations.
3. Make drawings of constellations, rockets, and spaceships.
4. Tell about the latest launch from Cape Kennedy.
5. Tell how the sun helps us.
6. Discuss some of the ways that help us learn about things.
7. Make up your own star pictures or constellations.
8. Find out how far away some stars are.
9. Find out how the days of the week and the months got their names.

INTERMEDIATE

1. Prepare charts to illustrate Kepler's Laws of Planetary Motion.
2. Find out about different kinds of telescopes and how they are used.
3. Make murals depicting some thrilling moments of scientific discoveries.

4. Make a chart of the heavens as they appear at the time of your planetarium visit.
5. Form committees to study and report on early scientists and their discoveries.
6. Write a "you-are-there" story of some important incident in astronomical history.
7. Role-play a conversation between an astronaut and the ground control station.
8. Make a time line showing important events in the history of astronomy.
9. Demonstrate some geometric forms made by the stars.

UPPER

1. Make wooden or construction paper models of early astronomical instruments.
2. Build a reflecting or refracting telescope.
3. Report on the uses of radio telescopes.
4. Report on the ways man's beliefs have changed because of astronomical development.
5. Invite an astronomer to class to tell about recent advances in astronomical knowledge.
6. Use Aristotle's method to solve some problems. Discuss the advantages and disadvantages of that method.
7. Find out about new instruments that help us in our study of the heavens.
8. Build a simple launch vehicle model to show to the class.
9. Role-play the advantages and disadvantages of the Gregorian calendar.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Bethell, Jean: *The How and Why Wonder Book of Famous Scientists.* Grosset & Dunlap, New York, 1964. 48 p. (How and Why Wonder Books) P, I.

Blow, Michael and Multhauf, Robert P.: *Men of Science and Invention.* Golden Press, New York, 1961. 153 p. (American Heritage Junior Library) I

Bolton, Sarah K.: *Famous Men of Science.* Thomas Y. Crowell Co., New York, 1946 (rev.) 308 p. I, U

Conant, James B.: *Science and Common Sense.* Yale University Press, New Haven, Connecticut, 1951. 371 p. A

Freedman, Paul: *The Principles of Scientific Research.* Pergamon Press, New York, 1960 (rev.) 222 p. A

Gregor, Arthur S.: *A Short History of Science, Man's Conquest of Nature from Ancient Times to the Atomic Age.* Macmillan, New York, 1963. 229 p. A

McSpadden, J. Walker.: *How They Blazed the Way; Men Who Have Advanced Civilization.* Dodd, Mead & Co., New York, 1959. 284 p. I, U

Miers, Earl S.: *The Story Book of Science.* Rand, McNally & Co., New York, 1959. 159 p. I

Rapport, Samuel B. and Wright, Helen: *Science: Method and Meaning.* New York University Press, New York, 1963. 258 p. (The New York University Library of Science) A

Ritchie, A. D.: *Studies in the History and Methods of the Sciences.* Aldine Publishing Co., Chicago, 1958. 230 p. A

Roman, Colin: *The Astronomers.* Hill and Wang, New York, 1964. 232 p. A
Ruchlis, Hyman: *Discovering Scientific Method, with Science Picture Puzzles.* Harper and Row, New York, 1963. 190 p. U
Sterling Publishing Co.: *Picture Book of Pioneers in Science.* Sterling Publishing Co., New York, 1962. 164 p. I, U
Stevers, William Oliver: *Famous Men of Science.* Dodd, Mead & Co., New York, 1952. 164 p. U
Sullivan, Navin: *Pioneer Astronomers.* Atheneum Publishers, New York, 1964. 156 p. I, U
Williams-Ellis, Amabel: *They Wanted the Real Answers.* G. P. Putnam's Sons, New York, 1958. 64 p. I, U

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

Aristotle and the Scientific Method. Coronet Films, Chicago, 1959. 13½ min. sd. color, b-w. P, I, U
The Astronomer at Work. McGraw-Hill Text Films, New York, 1959. 40 fr. si. color. U
Birth of Science and the Scientific Method. Curriculum Materials Corp., Philadelphia, 1962. 48 fr. sd. color. I
Charting the Universe. Encyclopedia Britannica Films, Wilmette, Ill., 1963. 13 min. sd. color. U, A
The Dream that Wouldn't Down. National Aeronautics and Space Administration, 1965. 27 min. sd. b-w. I, U, A
Dr. Posin's Giants, I. National Instructional Television Library, New York, N. Y. 1961. 30 min. each, sd. b-w (series of 13 films) U
Finding out about the Universe. Society for Visual Education, Chicago, 1963. 42 fr. si. color. I
Galaxy of Elements. Creativision, Inc., N. Y., 1963. 20 min. sd. color. (produced by Swedish Institute of Stockholm) U, A
Galileo. Coronet Films, Chicago, 1959. 13½ min. sd. color, b-w. I, U, A
Isaac Newton. Coronet Films, Chicago, 1959. 13½ min. sd. color, b-w. I, U, A
Myth, Superstition and Science. Encyclopedia Britannica Films, Wilmette, Ill., 1960. 13 min. sd. color. P, I, U
Our World of Science. Encyclopedia Britannica Films, Wilmette, Ill., 1956. 10 min. sd. color, b-w. P
Science Opens New Doors. New York Times Office of Educational Activities, N. Y., 1960. 55 fr. si. color, b-w. P, I, U, A
Trial Balance. National Aeronautics and Space Administration, 1965. 25 min. sd. color. I, U, A
Using the Scientific Method. Coronet Films, Chicago, 1952. 11 min. sd. color, b-w. U

II. THE PLANETARIUM TEACHES ABOUT MATHEMATICS IN SCIENCE

Alfred North Whitehead once observed that, "as mathematics becomes more abstract, it becomes more useful as a tool for dealing with the concrete."

Elementary-school teachers are interested in developing an understanding of the nature of mathematics as well as mathematical applications—a grasp and appreciation of the abstractions and structure of mathematics as well as the development of fundamental skills. Teachers are aware that new understandings and skills are more easily developed when a variety of approaches, procedures, and equipment are used. The planetarium's multidimensional techniques expose pupils in a unique manner to learnings in abstract mathematical ideas and to applications of mathematics in science. Since the materials and approaches are highly stimulating, the planetarium presents the teacher with a valuable vehicle for learning.

THE BRIDGEPORT PLANETARIUM VISIT, 1963–64

A Brief Account of the Class Experience

The orbiting planets, the constellations, the recurring seasons, time zones, and timekeeping are presented to the pupils in a visual setting. Understandings can be developed in minutes of observations that once took hours of study and research. In addition, these understandings are made available to a great range of abilities and not just to gifted pupils.

The lecturer introduces the pupils to man's first attempts to measure time by observing the alternation of light and darkness caused by the rotation of the earth on its axis in a single day. The changing phases of the moon are shown to demonstrate how early man first arrived at his conception of a month; early man's concepts of time were limited by these rough estimates.

The pupils are introduced to changes in the seasons, how early man eventually took note of the recurrence of the seasons, and how he finally arrived at the concept of a year. The tremendously long periods of time between these concepts and the countless astronomical observations involved in the development of these natural units of time are revealed to the pupils. The pupils are introduced to different kinds of calendars that men have used and how our present calendar is the result of precise mathematical calculations and over six thousand years of scientific endeavor.

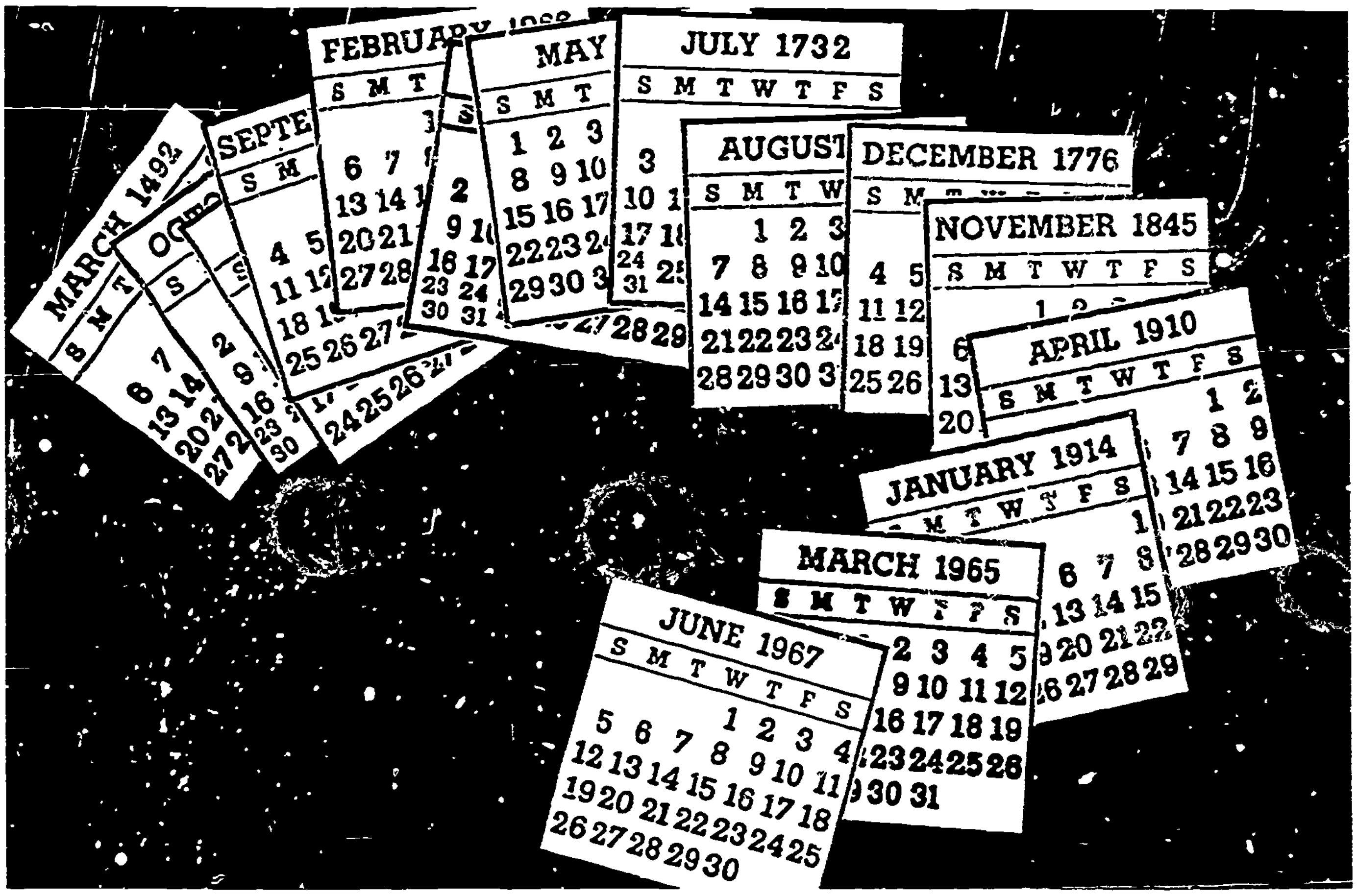
The dynamic relationships of the relative movements of the earth, moon, and sun can be readily understood within the planetarium, where their motion through space may be speeded up or slowed down to enable the pupils to make their own observations and to test their own hypotheses.

More precise methods of timekeeping and their relationships to astronomy through the ages are introduced. The development of sixty minute hours and sixty second minutes is presented and discussed. Today's world-wide observations of the stars and the use of precision instruments are presented to demonstrate the relationship between mathematics and astronomy. The navigator's sextant and the mechanical timepiece which make it possible for an individual to locate himself on earth are demonstrated in a realistic problem-solving fashion.

The auxiliary projectors of the planetarium make visible the imagined coordinates of latitude and longitude and give the pupils an opportunity to fix the position of a make-

believe ship lost at sea. The Prime Meridian which passes through Greenwich, England, is located, and during discussion of an around-the-world flight faint red lines appear to represent time zones. Questions are posed: What velocity must be maintained to make time "stand still"? What must the direction of travel be? If velocity were substantially increased, would the traveler move back in time? Where is the International Date Line? Why is it located on the globe opposite the Prime Meridian?

The imagined launching of a stationary communications satellite poses more questions: At the required altitude of 22,300 miles above the equator, what speed must be attained in order to "freeze" the satellite's position with respect to the earth? If this precise velocity is achieved, how long might the satellite be expected to stay aloft? From what fraction of the earth's area might we send and receive radio messages from such a satellite?



Measuring time with calendars.

The planetarium not only presents pupils with an opportunity to "see" but also to "feel" mathematical relationships. How would the pupils define a sphere? What properties does it have that might suggest a definition? It can be said that when the pupils are in the planetarium they are inside a hemisphere. This point can be used to develop understanding of the concepts of latitude and longitude and also prepares pupils for the Cartesian coordinate system with its system of integers.

The lecturer points out arrangements of stars that suggest geometric forms--circles, squares, parallelograms, rectangles, and various kinds of triangles. The children have an opportunity to locate geometric forms in the sky that are associated with the lecturer's stories from ancient mythology. The geometric forms take on new meanings that can be applied elsewhere.

The planetarium, which serves as a dimensional technological laboratory, can help elementary-school pupils develop concepts and applications that were beyond the reach of the greatest men of science in the past.

PIONEERS IN MATHEMATICS

Al-Khwarizmi	*(about 780–850 A.D.)*	Fibonacci	*(about 1175–1250 A.D.)*
Archimedes	*(287–212 B.C.)*	Gauss	*(1777–1855 A.D.)*
Descartes	*(1596–1650 A.D.)*	Leibniz	*(1646–1716 A.D.)*
Diophantus	*(about 250 A.D.)*	Newton	*(1642–1727 A.D.)*
Euclid	*(365–275 B.C.)*	Pythagoras	*(about 580–497 B.C.)*
Fermat	*(1601–1665 A.D.)*	Riemann	*(1826–1866 A.D.)*

VOCABULARY

abstraction calendar constellation geometric form hypothesis
International Date Line mathematical application phase Prime Meridian
satellite seasons sextant time zones velocity year

SOME QUESTIONS CONCERNING MATHEMATICS

1. Why is it necessary to measure as well as observe in science?
2. Of what use is a sextant to a mariner?
3. What geometric form do most satellite orbits take?
4. Why does a computer require another number system?
5. Why would a number system with a base of twelve have some advantages over our present system?
6. Does the North Star remain motionless in the sky?
7. Is it possible actually to gain a day or lose one in traveling?
8. How do we determine where to put the dividing lines between time zones?
9. Could you express "pi" in common fractions?
10. What advantages would the proposed world calendar have over our present calendar?
11. What is the relationship between mathematics and the sciences?
12. What does the length of a pendulum have to do with the period of its motions?
13. Why is it necessary to check even the most accurate clock mechanisms against the stars?
14. How can "carbon dating" and "radiation dating" help man to "read" history?
15. What is the difference between sidereal time and solar time?
16. Why does the astronomer use sidereal time?
17. Why must a sundial be adjusted for latitude?

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Look at pictures of constellations and describe their shapes (triangles, square, etc.).
2. Discuss how we can show that planets are of different sizes.
3. Find out why planets do not twinkle.
4. Find out how a sundial works. Make a model to try out.
5. Find out where constellations appear at different times during the year.
6. Compare the difference in size between early rockets and newer rockets.
7. Show the difference between a circle and an ellipse.

8. Find out why we have lines of latitude and longitude on globes.
9. Figure out a way to demonstrate Newton's second law of motion.

INTERMEDIATE

1. Show how a swinging pendulum can be used to demonstrate the rotation of the earth.
2. Find out how a sextant works and how it can be used.
3. Make a model of the sun and planets to show comparative sizes, using a scale of 10,000 miles = 1 inch.
4. Obtain a sphere of inflated plastic or styrofoam. Add lines to show latitude and longitude.
5. Learn and show the formulas for finding the area and volume of a sphere.
6. Locate apogee and perigee distances in an elliptical orbit.
7. Using the chalkboard, demonstrate Kepler's concept of equal area in equal time for planetary orbits.
8. Using sticks with labels, scale down on the playground the distances of the planets from the sun.
9. Trace the history of timekeeping devices up to the invention of the clock.

UPPER

1. Make a cross-staff and an astrolabe and measure the angular separations of various objects. Try it with some stars.
2. Make a pendulum and demonstrate Galileo's discovery of its time-keeping qualities.
3. Make models of cones using putty or modeling compound. Use a sharp knife to slice it into sections illustrating the circle, ellipse, parabola, and hyperbola.
4. Make an umbrella planetarium showing the constellations and the diurnal (daily) motion.
5. Demonstrate parallax and use protractors to measure angles to a distant object from both ends of a base line. Vary the distance of the object and relate it to the changing angles.
6. Find out about the librations of the moon. Figure out a way to demonstrate this phenomenon to the class.
7. List as many ways as you can by which mathematics can be used in preparing a rocket for launch.
8. Show how numbers can be written in different bases.
9. Make a time zone chart of the areas of the earth.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for Upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Ahrendt, Myrl: *The Mathematics of Space Exploration.* Holt, Rinehart and Winston, Inc., New York, 1965. 160 p. A

Asimov, Isaac: *Realm of Algebra.* Houghton Mifflin Co., Boston, 1961. 230 p. A

Bakst, Aaron: *Mathematical Puzzles and Pastimes.* D. Van Nostrand Co., Inc., Princeton, New Jersey, 1954. 206 p. A

Bell, Clifford and others: *Fundamentals of Arithmetic for Teachers.* John Wiley & Sons, Inc., New York, 1962. 389 p. A

Bendick, Jeanne, and Lavin, Marcia: *Take a Number: New Ideas plus Imagination Equal more Fun.* McGraw-Hill Book Co., New York, 1961. 63 p. U

Cajori, Florian: *History of Elementary Mathematics.* Macmillan Co., New York, 1917. 324 p. A

Freeman, Mae and Freeman, Ira: *Fun with Astronomy.* Random House, Inc., New York, 1953. 57 p. I

Hankin, Leon: *Retracing Elementary Mathematics.* Macmillan Co., New York, 1962. 418 p. A

Hardgrove, Clarence Ethel: *The Elementary and Junior High School Mathematics Library.* National Council of Teachers of Mathematics, Washington, D.C., 1960. 32 p. A

Meyer, Jerome S.: *Fun With Mathematics.* Fawcett Publications, Inc., Greenwich, Connecticut, 1958. 176 p. A

National Council of Teachers of Mathematics: *Enrichment Mathematics for the Grades.* National Council of Teachers of Mathematics, Washington, D.C., 1963. 367 p. A

Peck, Lyman C.: *Secret Codes, Remainder Arithmetic, and Matrices.* National Council of Teachers of Mathematics, Washington, D.C., 1961. 54 p. U

Reid, Constance: *From Zero to Infinity.* Thomas Y. Crowell Co., New York, 1960 (rev.) 161 p. A

Rosen, Sidney: *Galileo and the Magic Numbers.* Little, Brown and Co., Boston, 1958. 212 p. U

Schaaf, William L.: *Basic Concepts of Elementary Mathematics.* John Wiley & Sons, Inc., 1965. 386 p. A

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

The Calendar, Time and Temperature. Society for Visual Education, Chicago, 1963. 43 fr. si. color. P, I

Discovering Numerals. Film Associates of California, Los Angeles, Calif., 1964. 9 min. sd. color P

How Man Learned to Count (Arithmetic). Association Films, New York, 1958. sd. 30 min. color. U, A

Introducing Shapes (Common Geometric Figures). Curriculum Materials Corp., Philadelphia, 1959. 52 fr. si. color. P

Modern Mathematics: Telling Time. Society for Visual Education, Chicago, 1964. 51 fr. si. color. P, I

Modern Mathematics: Time Measurement-Calendar. Society for Visual Education, Chicago, 1964. 51 fr. si. color. P, I

Number Bases other than Ten. McGraw-Hill Book Co., New York, 1963. 35 fr. si. color. U

Numbers through the Ages. Webster Publishing Co., St. Louis, Mo., 1961. 41 fr. si. color. P, I

Our Set of Numbers. Number Films, Northridge, California, 1962. 41 fr. si. color. P, I

Patterns in Numbers. Filmstrip-of-the-Month Club, New York, 1964. 39 fr. si. color. I

The Story of Measuring Time: Hours, Minutes, Seconds. Coronet Films, Chicago, 1963. 11 min. sd. color. I, U

Things in Groups. Curriculum Materials Corp., Philadelphia, 1958. 29 fr. si. color. I, U

Understanding Number Bases. Webster Publishing Co., St. Louis, Mo., 1961. 55 fr. si. color. I, U

Words for Comparing. Curriculum Materials Corp., Philadelphia, 1958. 27 fr. si. color. I, U

Zero—The Forgotten Number. Eye Gate House, Jamaica, New York, 1955. 30 fr. si. color. I, U

Teacher and pupils using grid coordinates to locate positions on a globe, Bridgeport Public Schools.

III. THE PLANETARIUM TEACHES ABOUT LIGHT AND COLOR

The teacher concerned with building understanding of basic science can also play a major role in determining pupils' future attitudes about science. He can build a bridge of science understanding from the here-and-now world of functional concepts to the vastly more complex and largely unknown world of tomorrow's science. In working toward this goal, the study of nature's "secrets" offers important ways to capitalize on children's natural curiosity and eagerness. The rainbow, for instance, offers not only enjoyment but an opportunity to learn. It can be used not only to explain natural phenomena but also to help motivate pupils toward building rainbows of their own.

A living unit in light and color finds the class examining color in both aesthetics and in safety education. What colors are the most cheerful? What combinations of colors are most pleasant? Why are stop lights red? Why are some street lights yellow?

Questions can lead to experiments which will determine the facts and help pupils to check their findings against those of adult researchers. Instead of being told that they should have enough light for reading, pupils can investigate for themselves. They will find that different activities require different intensities of light and that different materials reflect light in varying degrees. They can study the actions of the eyes in seeing so that they will understand the real implications of eyestrain resulting from poor illumination. They can use a light meter to determine light intensity.

Pupils in the upper grades will begin to understand that light of different colors is energy of different wavelengths, many wavelengths being invisible to the naked eye. These pupils will enjoy experimenting with wavelengths outside of the visible spectrum. Using infrared film, they can take a picture in apparently total darkness, with only the "light" from a hot iron. They can visit a doctor's office or a hospital and look through a fluoroscope. They can search for answers to many questions such as: How is ultra-violet light used in geology? How is it used in crime investigation? How is the spectrograph used in astronomy to tell us what stars are made of?

THE BRIDGEPORT PLANETARIUM VISIT, 1963-64

A Brief Account of the Class Experience

For pupils who are experiencing their first planetarium visit, the atmosphere awakens a quality of attention seldom given in the classroom. The realism of the simulated outdoors environment, with its blue sky, slowly moving clouds, and brilliant sun—with the chirping of birds heard off in the distance and a high-flying jet leaving its contrail against the blue—awakens anticipation for an interest in the lecture to follow.

The lecturer asks, "What is the color of the sky?" The pupils chorus, "Blue." The lecturer says, "Our air is filled with countless droplets of water and particles of dust that are small enough to interfere with and scatter the shorter wavelengths of the sun's light, the blues and violets, and reflect this color to our eyes. Then, we say the sky is blue. But it isn't blue at all. Our dusty, moisture-laden air is reflecting the sun's blue light to our eyes. The sky is really black.

"One of our astronauts, while circling the earth a hundred miles above its surface, radioed back, 'It's noon and I can see the sun, moon, planets, and stars shining in a

perfectly black sky.' This was because he was not only so high above the earth, he was high above its atmosphere as well. There were no dust particles and moisture droplets to reflect light of any kind to his eyes. Would you like to see what an astronaut sees about 100 miles above the earth at noon? Very well, let's make believe we are looking out into the sky at noon 100 miles up."

The blue sky fades from view. The clouds disappear. The sky is black and filled with stars, planets, the moon, and the sun.

The narrator continues. "Now, let's get back to earth." The planets, moon, and stars disappear, and the clouds reappear. "We know that the sun's light is made up of all the colors of the rainbow. How do we know this? Have you ever looked at your reflection in a mirror and seen the rainbow of color near the edge of the mirror? Where does the color come from? Have you ever seen a rainbow? Have you ever seen a rainbow of colors when you were squirting water in a fine mist from a garden hose? Have you ever seen a rainbow of colors after a rainfall on an oil spot on the street?

"Many years ago, in 1666, a famous scientist named Isaac Newton decided to conduct an experiment. Here we see him doing just that. He has made a little hole in the window shade so that a ray of sunlight is passed through a glass prism, a little triangular wedge of glass, on the table. Although the ray of sunlight entering the glass wedge appears white, a rainbow of colors is coming out of the other side of the prism. See it there? He called it a spectrum.

"He wondered why white light entering the prism turned different colors when it left the prism. Then he wondered if white light was made up of all the colors of the rainbow mixed together. To find out, he placed another prism right into the spectrum and covered all of the colors except red. He let the red light go through the second prism and only red came out the other side. That proved that the single colors could not be broken down into further colors. Next, he turned the second prism over and, passing the rainbow of colors through it, found that on leaving the other side the colors combined to make white light all over again. In this way, Newton proved that white light is actually all of the colors mixed together and that our eyes aren't sensitive enough to separate them one at a time."

The word picture you have read, describing only part of the planetarium's presentation dealing with light and color, would take about six or seven minutes of a forty-five minute presentation. Later on, the lecturer discusses the stars, points out their different colors, and indicates that this is evidence of their varying temperatures. Red stars are red hot; blue stars are much hotter still. The lecturer then simulates a howling, crashing, thunder-and-lightning storm and follows it, as the sun reappears, with a beautiful rainbow. After the rainbow, he magnifies a raindrop to show how it produces the colors of the spectrum, just as a prism does.

At the end of the presentation, the pupils are given materials that review major points in the demonstration. The understandings the planetarium develops may then be reinforced at home or in school.

PIONEERS IN THE SCIENCES OF LIGHT AND COLOR

Daguerre	*(1789-1851 A.D.)*	Hero	*(about 3rd Century B.C.)*
Doppler	*(1803-1853 A.D.)*	Hertz	*(1857-1894 A.D.)*

Huygens	*(1629-1695 A.D.)*	Newton	*(1642-1727 A.D.)*
Maxwell	*(1831-1879 A.D.)*	Roentgen	*(1845-1923 A.D.)*

VOCABULARY

aesthetics contrail fluoroscope functional concept geology infrared light intensity light meter spectrograph spectrum visible spectrum wavelengths

SOME QUESTIONS CONCERNING LIGHT AND COLOR

1. **What is light?**
2. **What is shadow?**
3. **Why is sunlight sometimes referred to as "light energy"?**
4. **Are there colors in the sun's light?**
5. **Does the moon shine by its own light?**
6. **Could you see the earth from the moon?**
7. **Why do the sun and moon turn red-orange near the horizon?**
8. **Why do leaves change colors in the fall?**
9. **Is our sun a star?**
10. **What are aqueous meteors?**
11. **Is an X-ray or an infrared ray light?**
12. **Is it possible to make white light out of a rainbow of colored lights?**
13. **What do you use to convert light to electrical energy?**
14. **Does light always travel in straight lines?**
15. **What is the difference between the light from planets and that from stars?**
16. **What is a laser? What are some of its possible uses?**
17. **What is meant by a "light year"?**
18. **Why is it necessary to use photography in astronomical data gathering?**

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Experiment by mixing pigments of paint. What colors do you see when you mix different combinations of pigments of paint?
2. Put a pencil in a glass that is half filled with water. How does the pencil look?
3. Look through a prism or the corner of a square aquarium that light is passing through. What do you see? Can we produce this effect in any other ways?
4. Experiment with many different objects, beginning with a mirror, to see which objects will reflect enough light to produce an image.
5. Shine a flashlight on the wall in the darkened classroom. Put a rounded piece of paper partly over the lens of the flashlight. What happens to the image on the wall?
6. Find out if stars are of different colors.

INTERMEDIATE

1. Write a report on the care of the eyes, including the use of eyeglasses and contact lenses.
2. Illustrate the difference between reflected and refracted light.
3. Draw a diagram showing how reflecting and refracting telescopes work.

4. Fill a glass bottle with water and hold it up to the sun. What do you see? Why?
5. Make a drawing of your classroom, and with a photoelectric light meter measure and label the different intensities of light that you find. Find out the minimum of illumination considered adequate for reading. Mark the areas of the classroom that are below minimum.
6. Draw and label the parts of the eye and describe the phenomenon of sight.
7. Observe the moon on a clear evening and report the changes in its color with its height above the horizon. How do you explain these color changes?
8. Make a collection of optical illusions. Explain why the eye is fooled—what clues are causing these misjudgments?
9. Ask your dentist to show you X-rays of teeth and explain how the X-ray machine works.

UPPER

1. Visit a printing plant where color printing is done. What colors of inks are combined?
2. Experiment with growing seeds under different conditions of light. What is the process of photosynthesis?
3. Have a photographer friend discuss color photography with you. What three or four colors are combined to make color negatives; color positives?
4. How do light waves differ from sound waves? Illustrate the wave principle and the difference between light and sound waves.
5. What is the meaning of "focal length"? Talk with a photographer and find out what the focal length of a lens means with respect to the photograph.
6. Illustrate and explain how the curved mirrors at the amusement park distort your image.
7. Illustrate the different phases of the moon showing h~~ the reflected light from the sun gives different shapes (apparently) to the moon.
8. Demonstrate various kinds of eclipses, using balls of different sizes and a flashlight.
9. Write a report on color blindness. What is it? How do we determine if a person has it? Is it dangerous? Can it be corrected? Is it inherited?

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Adler, Irving: *Color in Your Life*. John Day Co., Inc., New York, 1962. 160 p. I, U

Beeler, Nelson F. and Branley, Franklin M.: *Experiments With Light*. Thomas Y. Crowell Co., New York, 1958. 143 p. I, U

Blackwood, Paul E.: *Light and Color*. Grosset and Dunlap, Inc., New York, 1963. 48 p. I, U

Dogigli, Johannes: *The Magic of Rays*. Alfred A. Knopf, Inc., New York, 1961. 264 p. A

Duvoisin, Roger: *Day and Night*. Alfred A. Knopf, Inc., New York, 1960. unpaged. P

Healey, Frederick: *Light and Color*. John Day Co., Inc., New York, 1962. 48 p. I

Meyer, Jerome S.: *Prisms and Lenses.* World Publishing Co., Cleveland, 1959. 64 p. I, U

National Aeronautics and Space Administration. *The Laser.* National Aeronautics and Space Administration, Washington, D.C., 1966. 8 p (NASA FACTS, Vol. III, No. 6)

Neal, Charles D.: *Exploring Light and Color.* Children's Press, Inc., Chicago, 1964. 156 p. I, U

Reinfeld, Fred: *Rays: Visible and Invisible.* Sterling Publishing Co., New York, 1958. 204 p. U

Ruchlis, Hyman: *The Wonder of Light, A Picture Story of How and Why We See.* Harper and Row, New York, 1960. 154 p. I, U

Steiner, Charlotte: *My Slippers Are Red.* Alfred A. Knopf, Inc., New York, 1957. unpaged. P

Thackeray, Andrew: *Astronomical Spectroscopy.* Macmillan Co., New York, 1961. 256 p. A

Wolff, Janet: *Let's Imagine Colors.* E. P. Dutton and Co., New York, 1963. unpaged. P

Zarchy, Harry: *Wheel of Time.* Thomas Y. Crowell Co., New York, 1957. 133 p. U

Zolotow, Charlotte S.: *The Night When Mother Was Away.* Lothrop, Lee and Shepard Co., Inc., New York, 1958. (unpaged) P

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

Bouncing and Bending Light. Filmstrip House, New York, 1959. 32 fr. si. color. P

Charting the Universe. Encyclopedia Britannica Films, Wilmette, Ill., 1963. 13 min. sd. color. U, A

How Light Helps Us. Filmstrip House, New York, 1959. 33 fr. si. color. P

How Light Travels. Filmstrip-of-the-Month Club, Inc., New York, 1959. 39 fr. si. color. I

How Our Eyes See. Filmstrip House, New York, 1959. 30 fr. si. color. P

How Sunshine Helps Us. Coronet Films, Chicago, 1961. 11 min. sd. b-w, color. P

Learning about Light. Encyclopedia Britannica Films, Wilmette, Ill., 1955. 8 min. sd. b-w. I, U

Light. Eye Gate House, Jamaica, New York, 1964. 43 fr. si. color. I, U

Light All About Us. Coronet Films, Chicago, 1954. 11 min. sd. color, b-w. P

Light and Color. Encyclopedia Britannica Films, Wilmette, Ill., 1961. 13½ min. sd. color. I, U

Light and Color. Eye Gate House, Jamaica, New York, 1964. 43 fr. si. color. I, U

Light and How it is Refracted. Society for Visual Education, Chicago, 1958. 44 fr. si. color. U

Light and Lenses. Filmstrip House, New York, 1962. 32 fr. si. color. I, U

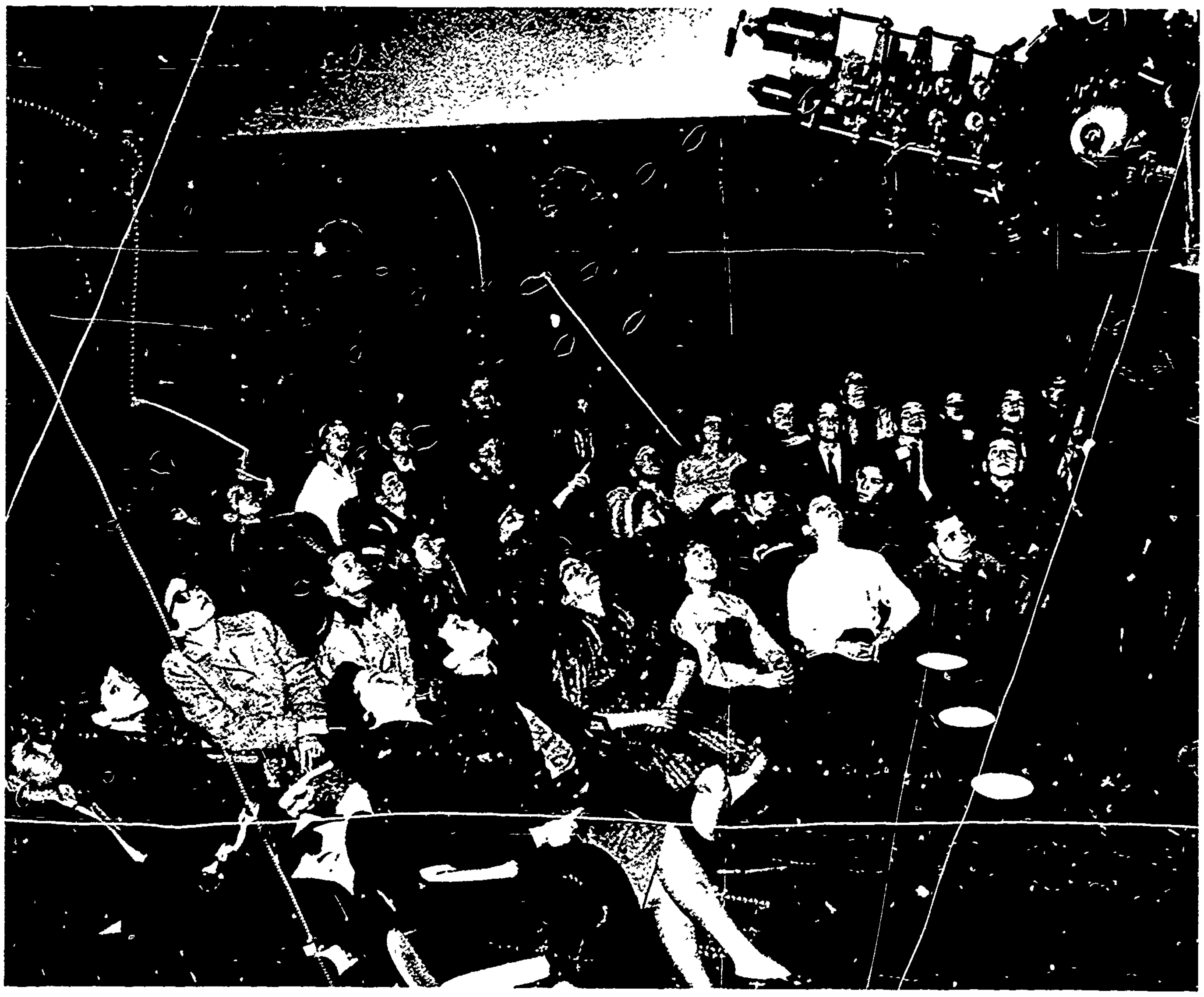
Light and Vision. Filmstrip House, New York, 1962. 33 fr. si. color. I, U
Light in our Daily Lives. Eye Gate House, New York, 1952. 23 fr. si. color. I
The Night the Moon was Late. Eye Gate House, New York, 1961. 42 fr. sd. color. U
Sources of Light. Filmstrip House, New York, 1962. 36 fr. si. color. I, U
Strange Case of Cosmic Rays. Bell Telephone, New York, 1957. 60 min. sd. color. P, I, U, A

IV. THE PLANETARIUM TEACHES ABOUT THE EARTH'S ATMOSPHERE

Man lives at the bottom of an ocean of air. This ocean, or atmosphere, was man's first scientific laboratory. Here he observed processes with his eyes which scientists today are studying with highly sophisticated instruments.

Conditions in the atmosphere determine whether the gang splashes in puddles or goes swimming or skating. Atmospheric conditions hang the rainbow in the sky, create the myriad patterns of snowflakes, and paint the sunsets. They also whip the winds into hurricanes, twist them into tornadoes, or flood, freeze, or bake the earth. Small wonder that early man imagined that the forces of the atmosphere demonstrated the wrath or pleasure of the gods.

No matter how comfortable an artificial atmosphere modern man may produce in his home or office, he probably will never lose his urge to control the elements. The small child delights in dodging the raindrops or throwing snowballs; the young man, in skiing or in climbing lofty mountain peaks. The scientist attempts to outwit the elements through four different processes: observation, understanding, prediction, and control.



Flash picture showing interest of pupils and teachers in Bridgeport Planetarium.

The observations of the ancients were limited to their immediate environs of earth and atmosphere. Today scientists' capabilities for observations of weather are expanding rapidly. The atmosphere is under continuous surveillance with operational weather satellites, and their observations are brought to meteorologists by automatic recording stations. Even the processes of the sun itself are being studied to determine their effect on the earth's weather. Today's observations are leading scientists to greater understanding of the nature of weather and, thereby, to greater ability to predict it. Scientists are also expressing confidence that before long they may provide man with the ability to control it.

Newspaper accounts are constant reminders of the weatherman's increasing skill in predicting weather. In contrast to the great losses suffered only a few years ago, thousands of lives and millions of dollars of property are safeguarded today through more accurate prediction of the paths of storms, hurricanes, and tornadoes.

Man's capabilities for weather observation are improving and he is increasingly skilled at protecting himself from and adapting to the weather. However, it will be a long time before man becomes a "weather maker" on anv considerable scale—or even before he can decide with certainty that a program of control is practicable.

A possible decision on a program of weather control is only one of a whole complex of ideas that we as citizens must be equipped to answer in the years to come. We must determine policy regarding traffic in the skyways, air pollution, cloud seeding, communications transmission, and a host of other problems which will profoundly influence the quality of living. The curiosity and eagerness of today's children to know must be translated into the values and knowledge which are prerequisite to the making of tomorrow's scientific-social decisions.

THE BRIDGEPORT PLANETARIUM VISIT, 1963-64

A Brief Account of the Class Experience

The planetarium's semi-darkened room, with the mysterious machine casting weird shadows on the hemispheric ceiling, creates an atmosphere of anticipation and drama among the children. Gradually, the sky above is lighted brightly by the sun in a speeded-up journey overhead. Then, the sky becomes dark and the stars appear. The children learn that the sun alone does not cause daylight; but that the atmosphere also contributes.

The condition of the earth's atmosphere and its effects are dramatically presented. As the horizon gradually covers the sun, the bright orange-red hue of the western horizon appears. This is explained by the lecturer in terms of the absorption and scattering of the blue and violet colors in the many miles of dusty, moisture-laden atmosphere along the surface of the earth, while the reds and oranges filter through to be reflected. The pupils learn that even the colors of the sky depend on the condition of the atmosphere.

The lecturer points to the planets, which appear before the stars, and explains that they shine by reflecting the sun's light. Questions are posed: Why can the clouds no longer be seen? What has happened to them? Why is the sky so dark? Why do stars twinkle? Why do planets not twinkle?

Many other questions and answers are stimulated by these demonstrations: Where does the dust in the atmosphere come from? Why are there different kinds of clouds? Why do the clouds seem to change so often? Why does the sky usually appear to be blue? What causes the gray color in the sky?

A great deal has been learned in the seven minutes of this demonstration. Probably

more important are the topics that are raised and discussed after the demonstration. The lecturer may be asked to demonstrate rain, fog, sleet, hail, sun-dogs, thunder, lightning, haloes, smog, aurorae at the north and south poles, prismatic effects, rainbows, or selective absorption. The lecturer, with the many devices at his command, can produce a perpetual sunrise, change latitude or longitude, trace different kinds of eclipses, demonstrate reasons for the seasons, or track hurricanes, trace the trade winds and the doldrums, and point out Tiros and other satellites.

Thus, the control of time and phenomena afforded by the planetarium can help children develop concepts far beyond the reach of the usual classroom or textbook.

PIONEERS IN THE ATMOSPHERIC SCIENCES

Aristotle	*(384-322 B.C.)*	Lavoisier	*(1743-1794 A.D.)*
Boyle	*(1627-1691 A.D.)*	Pascal	*(1623-1662 A.D.)*
Cavendish	*(1731-1810 A.D.)*	Priestley	*(1733-1804 A.D.)*
Galileo	*(1564-1642 A.D.)*	Scheele	*(1742-1786 A.D.)*
Torricelli	*(1608-1647 A.D.)*		

VOCABULARY

absorption	atmosphere	aurora	auxiliary earth	cloud seeding	doldrums
eclipse	hemisphere	meteorologist	prism	sun-dogs	weather satellite

SOME QUESTIONS CONCERNING ATMOSPHERE

1. In what part of the sky does the sun appear red?
2. What color would the sky be if we were on the moon?
3. What causes day and night?
4. What is an aurora?
5. What extremes of temperature have been found on earth?
6. Why do atmospheric conditions sometimes interrupt radio and television communications?
7. Why doesn't the atmosphere drift off into space?
8. What is the relationship between the atmosphere and the transmission of sound?
9. Is the sun always shining on the earth?
10. Does air take up space?
11. Why do clothes lose weight when they dry?
12. Does water expand or contract when it freezes?
13. Why do planes fly at high altitudes in order to conserve fuel supplies?
14. What are clouds made of?
15. What happens to clouds when they disappear from view?
16. What causes an electrical storm?
17. Why would the temperatures on Mars differ so much more radically from day to night than those on earth?
18. What is the water cycle?
19. What is meant by the "unequal distribution" of the sun's heat on earth?
20. Where does weather happen—in the troposphere or the ionosphere?
21. Air is a mixture of nitrogen, water vapor, carbon dioxide, rare gases, dust, and what other common element?
22. Do other planets have atmospheres as dense as ours?

23. Why is it more difficult to cook at higher elevations?
24. Into what layers do we divide our atmosphere?

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Record the weather from day to day. Use symbols such as clouds, sun, etc. Substitute meteorological symbols later on.
2. Record average daily temperatures for two weeks. See if the children can predict the next day's average temperature.
3. Act out the earth's revolution around the sun and the moon's revolution around the earth.
4. Discuss how wind can be helpful and harmful.
5. Tell about ways in which air helps us.

INTERMEDIATE

1. Report on the problem of smog and its effect on health. What causes this condition? Can it be prevented?
2. Describe how weather information is collected. If possible, visit a weather bureau and get acquainted with the kinds of equipment that are used.
3. Talk to a pilot about his experiences with weather and weather reporting. What new developments are making it possible for planes to land and take off in conditions of zero visibility?
4. Compare different climates and their effect upon living things.
5. Discuss the factors which determine the climate of an area.
6. Take readings with a thermometer at different heights from the floor, in open windows, in the basement and in the attic. What conclusions can you draw about the movement of air?
7. Have class committees report on the lives and contributions of scientists who have contributed to our knowledge of weather.
8. Predict the tides by determining the exact time when the moon passes over the north-south line and the time when the highest tide occurs.
9. Look up and report on some of the fascinating accounts of mountain climbers and early pioneers in balloon ascension.

UPPER

1. Find out: What is the effect of the change of seasons upon architecture? Agriculture? Transportation? Clothing and other industries? Art? Literature and Music?
2. Select some destructive blizzard or other naturally destructive phenomenon and describe what took place. What loss of life and property? What precautions can be taken to avoid the condition or minimize the destruction?
3. Pupils who are interested in radio or television might report on the ionosphere and the influence of the atmosphere on transmission of programs.
4. Explain how the atmosphere serves man. What are the [illegible]ents that are used? How are they replaced?
5. Put a cup of water in a gallon can and heat to boiling. Remove the can from the stove and cap it tightly. What do you anticipate will happen? Explain how.

6. Do some research on the solar stove. Why is it being proposed for use in a country like India? How does it work?
7. Put a small amount of water in one jar and leave one empty. Tighten the lids on both and put them in the window where the heat of the sun will warm them. What happens? What accounts for this action? Why does moisture form on the outside of a cold drink glass on a hot day? Explain.
8. Describe the important role that dust particles play in the atmosphere.
9. How does a barometer help you to forecast weather? What does it measure? What would a barometer measure on the moon?
10. Report on ways to protect one's health under different climatic and weather conditions.
11. Compare the temperatures on two thermometers—one in a dish of water and one in soil. Make recordings at ten minute intervals. Try moving them into the sun, into the shade, etc. Compare them with the temperature of the air. Recordings could be listed or graphed.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for Upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Cortright, Edgar M.: *Space Exploration—Why and How.* National Aeronautics and Space Administration, Washington, D.C., 1965. 20 p. (EP-25) A

Darby, Gene: *What Is the Earth?* Benefic Press, Chicago, 1961. 48 p. P

__________: *What Is a Season?* Benefic Press, Chicago, 1959. 48 p. P

Fenton, Carroll Lane and Fenton, Mildred A.: *Worlds in the Sky.* John Day Co., New York, 1963. 96 p. I

Fisher, James: *Wonderful World of the Air.* Doubleday & Co., Inc., Garden City, New York, 1957. 68 p. I, U

Holmes, David C.: *Weather Made Clear.* Sterling Publishing Co., N. Y., 1965. 96 p. I, U

Knight, David C.: *The First Book of the Air, a Basic Guide to the Earth's Atmosphere.* Franklin Watts, Inc., New York, 1961. 67 p. I

__________: *The Science Book of Meteorology.* Franklin Watts, Inc., New York, 1964. 215 p. U, A

Kumin, Maxine W.: *Spring Things.* G. P. Putnam's Sons, New York, 1961. 48 p. P

__________: *Summer Story.* G. P. Putnam's Sons, New York, 1961. 48 p. P

__________: *Winter Friend.* G. P. Putnam's Sons, New York, 1961. 47 p. P

Lehr, Paul E., Burnett, W. H., and Zim, Herbert S.: *Weather: Air Masses, Clouds, Storms, Rainfall, Weather Maps, and Climate.* Golden Press, Inc., New York, 1957. 162 p. U

National Aeronautics and Space Administration: *Explorer XIX.* National Aeronautics and Space Administration, Washington, D.C., 1964. 8 p. (NASA FACTS, Vol. II, No. 2) A

National Aeronautics and Space Administration: *Interplanetary Explorer Satellites.* National Aeronautics and Space Administration, Washington, D.C., 1964. 8 p. (NASA FACTS, Vol. II, No. 1) A

National Aeronautics and Space Administration: *Launch Vehicles.* National Aeronautics and Space Administration, Washington, D.C., 1964. 8 p. (NASA FACTS, Vol. II, No. 5). Also color supplement (NASA FACTS, Vol. II, No. 5 Supplement.) I, U

National Aeronautics and Space Administration: *Meteorological Satellites and Sounding Rockets.* National Aeronautics and Space Administration, Washington, D.C., 1965. 24 p. (EP 27) I, U

National Aeronautics and Space Administration: *Nimbus.* National Aeronautics and Space Administration, Washington, D.C., 1964. 8 p. (NASA FACTS, Vol. II, No. 7) I, U

National Aeronautics and Space Administration: *Space, the New Frontier.* National Aeronautics and Space Administration, Washington, D.C., 1966. 96 p. (EP-6 rev.) I, U

National Aeronautics and Space Administration: *Tiros.* National Aeronautics and Space Administration, Washington, D.C., 1965. 8 p. (NASA FACTS, Vol. II, No. 12) I, U

Neurath, Marie: *Between Earth and Sky.* Sterling Publishing Co., New York, 1958. 36 p. I

Pilkington, Roger: *Ways of the Air.* Criterion Books, New York, 1962. 192 p. U

Piltz, Albert: *What Is Air?* Benefic Press, Chicago, 1960. 47 p. I

Ross, Frank Jr.: *Weather, The Science of Meteorology from Ancient Times to the Space Age.* Lothrop, Lee and Shepard, N. Y., 1964. 200 p. U

Syrocki, John: *What Is the Weather?* Benefic Press, Chicago, 1960. 45 p. I

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

Air and Its Properties. Young America Films, Inc., New York, 1953. 39 fr. si. b-w. I

Air and What It Does. Encyclopedia Britannica Films, Wilmette, Ill., 1962. 11 min. sd. color. P, I

Atmosphere and Its Circulation. Encyclopedia Britannica Films, Wilmette, Ill., 1945. 11 min. sd. b-w. U, A

Be Your Own Weatherman. Cenco Educational Films, Chicago, 1962. 13 min. sd. color. I, U

Clouds Above. Bailey Films, Inc., Hollywood, California, 1949. 9 min. sd. color. P, I, U

Concert for Clouds. Portafilms, Orchard Lake, Mich., 1955. 9 min. sd. color. P, I, U

Day and Night. United World Films, Inc., New York, 1949. 23 fr. si. b-w. U, A

The Earth's Atmosphere. Jam Handy Organization, Detroit, 1961. 37 fr. si. color. U

Great Winds: Part I, General Circulation. United World Films, Inc., New York, 1951. 10 min. sd. b-w, color. U, A

Great Winds: Part II, Distribution of Pressure and Winds. United World Films, Inc., New York, 1951. 10 min. sd. b-w, color. U, A

Heat and the Atmosphere. Filmstrip House, New York, 1960. si. 37 fr. color. P

How Air Helps Us. Coronet Films, Chicago, 1963. 11 min. sd. color. P

Inside the Weather. United World Films, New York, 1961. 13½ min. sd. color. P, I, U

Meteorology From Space. National Aeronautics and Space Administration, 1966. 20 fr. sd. color. I, U, A

Our Weather. Encyclopedia Britannica Films, Wilmette, Ill., 1955. 11 min. sd. b-w. I

Physical Characteristics of Air. Jam Handy Organization, Detroit, 1963. 40 fr. color. U

Sky Wise. Eye Gate House, New York, 1958. 39 fr. si. color. P, I

Tiros II, Experimental Weather Satellite. RCA, Inc., New York, 1961. 6 min. sd. color. (May be obtained from NASA, Washington, D.C.) P, I, U

Tiros/Nimbus Automatic Picture Transmission. National Aeronautics and Space Administration, 1965. 3¼ min. sd. color. I, U, A

Weather: Understanding Precipitation. Coronet Films, Chicago, 1962. 11 mn. sd. b-w, color. U

Weather: Understanding Storms. Coronet Films, Chicago, 1962. 11 min. sd. b-w, color. P, I, U

Weather: Why it Changes. Coronet Films, Chicago, 1962. 11 min. sd. b-w, color. U, A

What Makes Weather? Cenco Educational Films, Chicago, 1963. 14 min. si. color. I, U

What is Air Pressure? Jam Handy Organization, Detroit, 1961. si. 44 fr. color. U

Why Does the Wind Blow? Society for Visual Education, Chicago, 1965. 39 fr. si. color. I, U

Why Does the Weather Change? Society for Visual Education, Chicago, 1965. 39 fr. si. color. I, U

Why Seasons Change. Encyclopedia Britannica Films, Wilmette, Ill., 1960. 11 min. sd. b-w. I, U

Winds, Great and Small. Cenco Educational Films, Chicago, 1963. 12 min. sd. color, b-w. P, I, U

V. THE PLANETARIUM TEACHES ABOUT ENERGY AND MATTER

Elementary-school science textbooks usually define energy as "the ability to do work." As an abstraction this is difficult to grasp. Its illusiveness is well illustrated by the anecdote of an exchange between certain Swiss scientists and Einstein. When the latter suggested that a lump of coal possessed more energy than the whole German cavalry, they laughed and asked, if this were true, why had it not been noticed before. Einstein replied, "There is not the slightest indication that the energy will ever be obtainable."

Man's understanding of outer space depends upon his ability to unlock the secrets of "inner space"–the atom. Despite their almost indescribable difference in size, these "worlds" apparently are not very different in their behavior patterns.

A child, not unlike a scientist in his curiosity and desire to know, should be furnished with opportunities to come to grips with matter and energy in meaningful relationships. The teacher acts as guide in helping children puzzle out nature's secrets. But the teacher is limited in the means available for studying the complex world of matter and energy. Some of the data must be accepted on the basis of the research done by scientists.

Children can find means of demonstrating their understanding. Boys and girls might describe a distant house, which appears solid and possessed of different properties than are found in nearer houses but which, on closer inspection, will be found quite similar to other buildings. Both will have like properties and windows and open areas as well. Girls can point out the similarity of ingredients in various recipes which produce quite different dishes.

Gravity is another phenomenon which can be discussed in the classroom. Man's success in defying gravity has been based upon his ability to muster and sustain a force equal to, or greater than, the pull of gravity upon him. Thus his age old dream of flying has come true. An airplane pulls or pushes its way through the ocean of air with its propellers or jets and is lifted by the reduced air pressure on the top of its wings created by the shape of the wing. The rocket, on the other hand, does not depend upon the presence of air. As a matter of fact, air represents a resistance and hindrance which, like gravity, must be overcome if the rocket is to continue its climb into the atmosphere. With rockets, we are able to lift a small mass into orbit where no further energy is needed to maintain it at orbital speeds for an indefinite period of time. In such a state, there is an equalization of forces brought about through a balance of inertia and gravity.

In the case of an elliptical orbit, the satellite's speed constantly changes, reducing to a minimum as it reaches apogee, its greatest height above earth. It speeds up to maximum as it reaches perigee, its nearest point to earth. The high speed which it attains at perigee enables it to move up to apogee, so that the cycle can thus be constantly repeated.

The moon, along with all other bodies in the solar system, is influenced by the sun's pull of gravity. If, by some chance, another body were to come hurtling by and exert a compelling gravitational force of sufficient magnitude, it might pull the moon, the earth, and other planets, including even the sun, into orbits around itself.

Given a few of these principles, the fertile imagination of pupils can explore many possibilities.

THE BRIDGEPORT PLANETARIUM VISIT, 1963–64

A Brief Account of the Class Experience

Pupils visiting the planetarium have an opportunity to inspect exhibits showing a cut-away rocket engine, its thrust chamber, its propellant and oxidizer nozzles, and its cooling-jacket. A large section of a space station of the future invites viewers to walk through and look around. Life size models of astronauts at their duties, read-out from computers, and various astronomical exhibits are also on display.

In the planetarium chamber, the pupils prepare for a story of man's invasion of space. The lecturer describes the use of rockets by the Chinese in the 13th century as weapons of warfare against India. The realistic sounds of the battle scenes are heard as the angry, red trails of the rockets criss-cross the man-made sky above and the "invaders" attack a fortified position.

The pupils then learn of the further development of the war-rocket by a British lieutenant, William Congreve, and of its use in bombarding Ft. McHenry on September 14, 1814. This was the event which has been immortalized by Francis Scott Key in our national anthem with the words, "by the rockets' red glare."

The lecturer tells how, during the Napoleonic Wars, rockets were used by major European nations. Later, the U. S. Coast Guard used them to deliver life-saving lines to sinking ships. Some use was made of them during World War I, but it was not until 1919, when Dr. Robert H. Goddard developed the idea of a rocket engine using a liquid propellant, that the Space Age began to come into view.

The lecturer compares the old powder rockets with Goddard's liquid propellant vehicles and illustrates some of these comparisons in dramatic terms. He explains the geometry of the thrust chambers and the early failures due to inadequate cooling. He tells the story of the German scientists who achieved great success during World War II with the V-2 rocket by applying the theories and principles of Dr. Goddard and his German contemporary, Hermann Oberth. He projects cut-away drawings of that rocket and explains the various functions. He also mentions that many of these rockets were brought to this country along with German scientists so that rocket development might be continued.

Pictures are shown of the rocket-testing station at White Sands, New Mexico. Pupils witness launchings of the two-stage V-2 Wac Corporal assembly, carrying instruments 240 miles above the earth. The lecturer traces the developments of the rocket vehicle and the orbiting of Sputnik I on October 4, 1957. Next, the audience is invited to accompany the lecturer "outdoors" in the early morning hours to see Sputnik moving against the background of stars. Its telemetry is heard and explained with the tape recorder.

Pupils are also told of some of the highlights of other successful American and Russian launchings and various types of power supplies. Those included are rocket engines, solar batteries, and atomic reactors.

The foregoing takes only a few minutes of the typical planetarium presentation. Depending upon the interests of the class, such a program could proceed to examine inner space—the microcosmic "universe in miniature," where power potential is just beginning to be realized. Or, the program could further explore the forces of gravity of the macrocosmos. There is always time made available for questions which develop naturally, or for special requests which have been communicated to the lecturer in advance.

Most presentations reach each pupil in some way and make the world about him appear to be more understandable. Thus, the pupils leave the planetarium with confidence that their aroused curiosity may be satisfied.

PIONEERS IN THE SCIENCES OF MATTER AND ENERGY

Archimedes	*(about 287–212 B.C.)*	Galileo	*(1564–1642 A.D.)*
Boyle	*(1627–1691 A.D.)*	Lavoisier	*(1743–1794 A.D.)*
Cavendish	*(1731–1810 A.D.)*	Newton	*(1642–1727 A.D.)*
Dalton	*(1766–1844 A.D.)*	Priestley	*(1733–1804 A.D.)*
Democritus	*(about 490–370 B.C.)*	Rontgen or Roentgen	*(1845–1923 A.D.)*

VOCABULARY

apogee atomic reactor cooling jacket data gravity gravitation inertia orbit perigee propellant solar batteries Sputnik telemetry thrust weightlessness

SOME QUESTIONS CONCERNING MATTER AND ENERGY

1. What effect does radiation have on plant growth?
2. What would happen if the sun stopped shining?
3. What fuel is most likely to be used for interplanetary travel?
4. What force resists man's efforts to launch space vehicles?
5. Why would a person on the moon need to be shielded from radiation from space when he would not require this protection on earth?
6. Does an object fall faster near the earth or out in space?
7. Are most satellite orbits circular or elliptical in shape?
8. Explain the concept of a "fixed satellite."
9. How does the sun produce its energy?
10. Why is it necessary to set off a hydrogen bomb with an atomic explosion?
11. Is it possible to create matter?
12. What element is the largest constituent in stars?
13. What are the forms or states of matter?
14. What are the most promising energy sources for the future?
15. What is a cyclotron? What does it do?
16. What is the smallest particle of matter called? What other particles of matter have we found?
17. What do we mean by weightlessness?
18. How does weight vary with altitude?
19. How does circular orbital velocity vary with altitude?

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Experiment to find out the easiest way to move a heavy object.
2. Move the horizontal plank on the teeter-totter to various positions. How does the position of the point of contact of the plank affect the effort to push it up and down?
3. Experiment and read to see if many materials can be changed from one state to another easily. Find out why or why not.
4. Put a jar full of water in a paper bag. Place the bag in the freezing compartment of a refrigerator. What happens when the water freezes?

5. Find out if fish can live in ice.
6. Experiment to find some materials that will be attracted to a magnet.
7. Find out about different kinds of magnets. How are they found or made?
8. Read to find out if the earth is a magnet.

INTERMEDIATE

1. Make models to represent atoms and molecules.
2. Construct simple crossword puzzles using the vocabulary words presented in this unit.
3. Write a report on spectrography. Learn the difference between absorption and bright line spectra. Study the spectra of some of the stars and some elements.
4. Make a spectroscope. Try to detect some elements with this spectroscope.
5. Make a collection of as many elements as you can find. A junk yard is a good source for many different metals. Polish the pieces and put them in sealed jars for a permanent collection. Make a card for each element listing its important physical properties.
6. Using some wire, a bar magnet, and a galvanometer, try to produce an electric current. Experiment to find out how to make the current stronger.
7. Make a list of several friction-reducing devices and procedures that we commonly use. Try to think of some new ways to reduce friction.

UPPER

1. Find out how the first atomic reactor was produced. Make a drawing showing the major parts and report to the class.
2. In reading about our space effort we see a lot about titanium, silicon, germanium, mylar, and LOX. Find out about one of these materials and how it is used in our space probe experiments.
3. How far would the moon travel in one day at the rate of 2280 miles per hour? Is there another way to determine how far it will travel if we don't know its speed, but know the distance from the earth to the moon?
4. Find out about the composition of sea water. How much gold is there in one ton of sea water? Find out about mining sea water for magnesium metal and bromine.
5. Compare the densities of the common metals. What is the average density of the earth? What do scientists conclude regarding the density of materials making up the core of the earth?
6. Find out how different rocks were formed. Explore the neighborhood to find examples of several different rocks and minerals. Start a collection with the ones you have found.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for Upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Andrade, Edward N. de C.: *An Approach to Modern Physics.* Garden City Books, Garden City, New York, 1957. 266 p. A

Asimov, Isaac: *Inside the Atom.* Abelard and Schuman, Ltd., New York, 1961. 185 p. U

Barrow, George: *Your World in Motion, the Story of Energy.* Harcourt, Brace and World, New York, 1956. 181 p. U
Blackwood, Paul E.: *Push and Pull, Story of Energy.* McGraw-Hill Book Co., New York, 1959. U
Bohr, Niels: *Atomic Physics and Human Knowledge.* John Wiley and Sons, Inc., New York, 1958. 101 p. A
Dutton, William S.: *One Thousand Years of Explosives: From Wildfire to the H Bomb.* Holt, Rinehart and Winston, Inc., New York, 1960. 183 p. A
Freeman, Ira M.: *Physics Made Simple.* Doubleday & Co., Inc., New York, 1956. 188 p. I, U
Glasstone, Samuel: *Sourcebook on Atomic Energy.* D. Van Nostrand Co., Inc., Princeton, 1958. (rev.) 641 p. A
Irving, Robert: *Energy and Power.* Alfred A. Knopf, Inc., New York, 1958. 140 p. I
Jaffe, Bernard: *Chemistry Creates A New World.* Thomas Y. Crowell Co., New York, 1957. 321 p. A
Neurath, Marie: *Too Small To See.* Sterling Publishing Co., Inc., New York, 1957. 36 p. P, I
Parker, Bertha Morris: *Matter and Molecules.* Row, Peterson and Co., Evanston, Ill., 1957. 36 p. I, U
Pearl, Carleton: *The Tenth Wonder—Atomic Energy.* Little, Brown and Co., Boston, 1956. 129 p. A
Read, John: *Through Alchemy to Chemistry.* Harper and Row, New York, 1957. 206 p. U
Ruchlis, Hyman: *Orbit: A Picture Story of Force and Motion.* Harper and Row, New York, 1958. 147 p. I, U

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

Earth is Born. Life Filmstrip, New York, 1953. 71 fr. si. color. I, U
Energy and Its Forms. Coronet Films, Chicago, 1961. 11 min. sd. color, b-w. I
Explaining Matter: Atoms and Molecules. Encyclopedia Britannica Films, Wilmette, Ill., 1958. 13 min. sd. color, b-w. P, I, U
Explaining Matter: Chemical Change. Encyclopedia Britannica Films, Wilmette, Ill., 1960. 11 min. sd. color, b-w. P, I, U
Galileo. Coronet Films, Chicago, 1959. 13½ min. sd. b-w, color. I, U, A
Gravity. Young America Films, New York, 1953. 43 fr. si. color. I, U
Gravity: How it Affects Us. Encyclopedia Britannica Films, Wilmette, Ill., 1960. 14 min. sd. color, b-w. I
Gravity: Weight and Weightlessness. Film Associates of California, Los Angeles, 1963. 11 min. sd. color. I, U

How Did our Solar System Begin? Charles Scribner's Sons, New York, 1956. 32 fr. si. color. P

How our Earth Began. Curriculum Materials Corporation, Philadelphia, 1960. 29 fr. si. color. I, U

Isaac Newton. Coronet Films, Chicago, 1959. 13½ min. sd. color, b-w. I, U, A

Man Discovers the Atom. Encyclopedia Britannica Films, Wilmette, Ill., 1959. 49 fr. si. color. I, U

Old Mother Sun. Encyclopedia Britannica Films, Wilmette, Ill., 1959. 14 fr. si. color. P

Our Sizzling Sun. Eye Gate House, Inc., Jamaica, New York, 1965. 29 fr. si. color. I, U

Planets in Orbit: The Law of Kepler. Encyclopedia Britannica Films, Wilmette, Ill., 1960. 10 min. sd. b-w. U

Sun: How It Affects Us. Coronet Films, Chicago, 1958. 11 min. sd. color, b-w. I, U

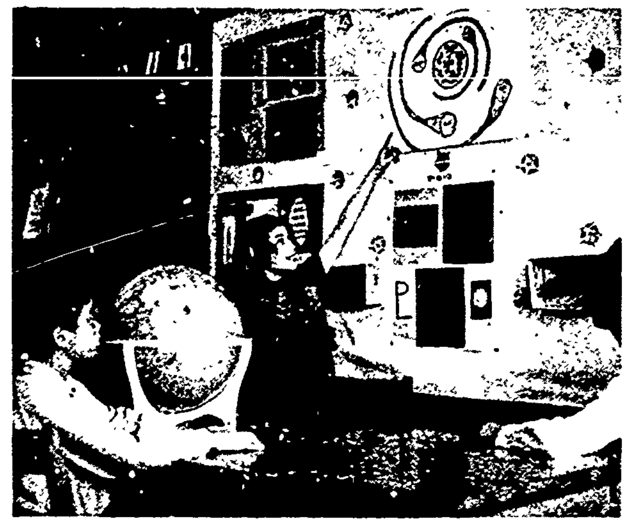
Understanding Matter and Energy. International Film Bureau, Chicago, 1960. 18 min. sd. color. U

What are Stars made of? International Film Bureau, Chicago, 1961. 16 min. sd. color. U

What are Things made of? Coronet Films, Chicago, 1960. 11 min. sd. color, b-w. P, I, U

Whys of Elementary Science—How Gravity Works. Filmstrip House, New York, 1961. 33 fr. si. color. P

VI. THE PLANETARIUM TEACHES ABOUT THE SOLAR SYSTEM



Learning about our solar system, Sharon, Connecticut, Public Schools.

Space is vast. But how can that concept be taught to ensure that elementary-school pupils fully understand? Shall the teacher tell the pupils of the distances between planets and stars? Will verbal explanations develop such a concept? Any teacher who has attempted to develop concepts in this way realizes the difficulties involved in such a limited approach. Without appropriate audio-visual aids, the development of abstract concepts is extremely difficult. The planetarium, one of the most natural teaching resources available, provides the vehicle by which some of the most abstract of concepts may be considered, developed, and understood.

Consider the concept of "wandering stars." Years ago, shepherds noticed that some stars seemed to be motionless and that in their fixed positions they outlined various shapes—animals, birds, and fishes. Because these stars appeared to be motionless, the people came to regard them as "fixed" stars. But other stars seemed to move against the background of the fixed star-pictures and these came to be known as "wandering stars." The wandering stars, of course, were planets. The word planet itself comes from a Greek word meaning "wanderer."

Because they had the ability to move, the planets were believed to be gods, endowed with supernatural powers, who controlled the lives of men and nations. The sun was regarded as the chief god because it furnished warmth and light and aided man in growing his food. The moon illuminated the earth by night so that hunters could track animals by its light. It also gave additional light for the harvesting crops. Even today the great, full moon of autumn is known as the hunter's moon or the harvest moon.

Eventually, men saw seven gods in the sky: the sun, the moon, and five "wanderers." One day was set aside for the worship of each. Since there were seven, we have a week of seven days, each day named for one of the seven gods.

The planetarium demonstrates the motions of the planets and of the fixed stars. It also develops concepts concerning relative distances between the planets and their satellites. It shows the relationship of the comets and meteoroids to the solar system and gives children some relatively simple, easily understandable ideas about the colors in the sky. The planetarium stimulates visualization, presents difficult astronomical concepts in a realistic setting, and serves as a springboard to other fields of knowledge.

THE BRIDGEPORT PLANETARIUM VISIT, 1963–64

A Brief Account of the Class Experience

At the planetarium, the lecturer shows the audience an instrument in the center of the auditorium, calling it a "multi-projector" or a "time-machine," which can take the

audience back in time to see the skies our ancestors saw, or forward to view the skies that future generations will see. It can also take the children to any geographic point on the surface of the earth.

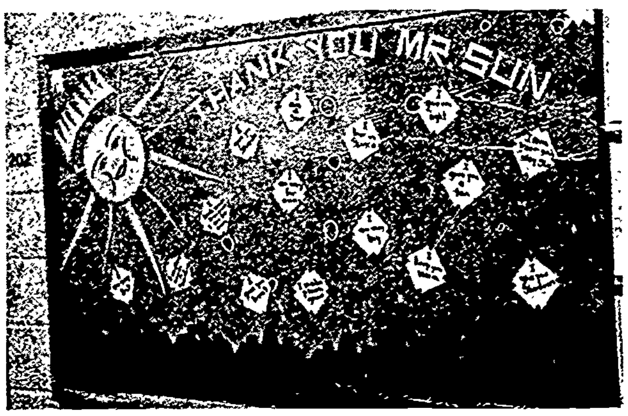
The lecturer begins his presentation by discussing one of the various theories of the origin of the solar system. According to this theory, billions of years before history began space was populated by dormant atoms, the building blocks of the universe. One of these atoms began to move, and its gravitational field reached out and touched a nearby atom. The combined attraction of these two atoms drew others together until trillions of atoms formed a cloud called the "primordial nebula," which means the very first cloud. As more atoms crowded together in the center the pressure increased.

In the planetarium, the children see a cloud increase in brilliance until, as the lecturer points out, the pressure has reached a point where the temperature at the cloud's center becomes hot enough to make it glow. The lecturer explains how, according to this theory, the sun was formed from the glowing center of the cloud, while the planets were formed by gases that condensed in the spiral arms of the nebula. As he speaks, the sun appears with the earth and the five visible planets circling around it.

The lecturer identifies the planets, describes their periods of revolution, diameters, and the number of satellites which revolve around some of them. He speaks briefly of Kepler and his contributions to astronomy and mathematics, and points out how the planets move in accordance with the principles which we know as Kepler's Laws of Planetary Motion, speeding up when they near the sun and slowing down at greater distances from it.

The lecturer then produces a daytime sky. It is late afternoon, and the sun appears to be crossing the sky from east to west. The lecturer points out, however, that the sun does not really cross the sky and that it is the earth which is moving. As the earth spins, the horizon spins with it. In the west, it lifts upward to meet the sun, while to the east it dips downward away from the sun.

As the horizon rises and the sun "sets," the sky assumes a reddish-orange color, due to "selective absorption," a process whereby dust particles and moisture droplets absorb or soak up and scatter the short wavelengths of color, i.e., the blues and the violets, passing only the long wavelengths of red and orange. It is called selective absorption because these particles and droplets "select" or "choose" which colors to soak up or absorb. At sunset the sun's rays pass through more atmosphere causing most of the blue light to be scattered, leaving the red and orange colors to be seen.



Learning about the sun, Trumbull, Connecticut, primary grades.

The lecturer can also "unlock time" so that his audience can watch the planets as they move among the stars at a rate adjusted to a time-compressed month. He can demonstrate how the planets revolve around the sun from west to east. He can direct the audience's attention to Mars, which slows down, stops, and begins moving from east to west. This illusion is known to astronomers as retrograde motion. He can conduct the audience on a trip to the surface of one of the other planets in order to observe the sky from a different vantage point.

The pupils can begin to understand the magnitude and complexity of the universe and their place in it.

PIONEERS IN ASTRONOMY

Aristarchus	*(about 202–150 B.C.)*	Galileo	*(1564–1642 A.D.)*
Brahe	*(1546–1601 A.D.)*	Herschel	*(1792–1871 A.D.)*
Copernicus	*(1473–1543 A.D.)*	Kepler	*(1571–1630 A.D.)*
Foucault	*(1819–1868 A.D.)*	Newton	*(1642–1727 A.D.)*
Ptolemy	*(about 100–170 A.D.)*		

VOCABULARY

comet dormant fixed stars gravitational field horizon Mars
meteoroid nebula planet supernatural wandering stars

SOME QUESTIONS CONCERNING THE SOLAR SYSTEM

1. **What are some features of the moon?**
2. **What are the names of the major planets?**
3. **What are the names of the minor planets?**
4. **Who discovered Uranus?**
5. **Do planets shine by their own light?**
6. **How is a planet different from a star?**
7. **Why is a comet's tail always pointed away from the sun?**
8. **How big is a meteor? A shooting star?**
9. **How far away is the moon in miles? In travel time?**
10. **What causes a lunar eclipse? Solar eclipse?**
11. **Does the fact that we always see the same side of the moon mean that the moon does not rotate?**
12. **How far away is our moon? Venus? Sun? Mars?**
13. **Why does the temperature of the moon vary so much from night to day?**
14. **Why is Mercury's orbit around the sun so much shorter than the earth's?**
15. **What made the ancient peoples believe that the earth was the center of the universe?**
16. **What makes our moon seem to change its shape?**
17. **Why can we see our moon in the daytime?**
18. **What keeps our moon in its orbit?**

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Look at the night sky. Do all the objects behave the same? What differences do you notice? Tell the class about them.
2. Look at the daytime sky to see if you can find the moon. Can you see the moon in the daytime?
3. Imagine that you are Galileo. Tell about your first impressions on observing the sun, moon, and the planets.
4. Draw a scene showing the landscape of the moon or close-up views of some of the planets.
5. Look at some of the Ranger photographs of the moon. Discuss some of the features shown in the pictures.

6. Pretend that you are interviewing a visitor from another planet. Role-play the interview in class.
7. Find pictures of the sun's corona. Find out how these pictures were taken.

INTERMEDIATE

1. Discuss what is meant by the "tilt of the axis." Draw diagrams to illustrate the earth's relationship to the sun at different seasons.
2. Compute the distance light travels in one hour, one week, one month, and one year.
3. Create a story whereby you are visited by a person from another planet. Write it as a feature story for a newspaper.
4. Pretend you are back in the time of Columbus. Convince a boy or girl of your age that the earth is round.
5. Make a table showing the comparative distances of the planets from the sun.
6. Make a chart showing the comparative diameters of the planets. Draw them to scale. How do they compare with the sun?
7. Read about Halley's comet. What historical events occurred when it appeared? Why do people tend to regard comets as evil omens?
8. Illustrate surface features on celestial bodies by making dioramas.
9. Count the visible meteors on various nights.
10. View the western horizon on successive evenings just after sunset and report what you observe concerning the relationship between the setting sun's position and the position of the stars.

UPPER

1. Observe the "moons" of Jupiter through a telescope and chart their positions during successive days. Try to calculate the periods of revolution of the four largest satellites.
2. Find out about some ancient conceptions of the universe: Egyptian, Grecian or Babylonian.
3. Using Bode's Law show the distance of the planets. Compare this with their actual distances.
4. Pretend that you are in ancient Egypt. Knowing what you know now about the solar system, how would you convince an ancient Egyptian astronomer that the sun is at the center of the solar system and that the planets go around the sun?
5. Write a story, based on your study, about the creation of a solar system as seen from a distant point in space.
6. Make a model of our solar system showing the order of the planets.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Adler, Irving: *The Sun and Its Family.* John Day Co., New York, 1958. 128 p. U

Asimov, Isaac: *The Double Planet.* Abelard and Schuman Ltd., New York, 1960. 158 p. U

Binder, Otto: *Planets.* Golden Press, Inc., New York, 1961. 54 p. P

Buchanan, Cynthia D.: *The Earth in Space.* Macmillan, New York, 1963. 114 p. (Programmed Geography Series) I

Cortright, Edgar M.: *Space Exploration—Why and How.* National Aeronautics and Space Administration, Washington, D.C., 1965. 20 p. (EP-25) A

Costa, Arthur L.: *Space.* Teachers Publishing Corporation, Darien, Conn., 1964. 96 p. A

Dodson, R. S.: *What You Should Know About Meteors and Meteorites.* Morehead Planetarium, Chapel Hill, North Carolina, 1960. 20 p. A

Fenton, Carroll Lane: *The Moon for Young Explorers.* John Day Co., New York, 1963. 64 p. P

Fisher, George Clyde: *Exploring the Heavens.* Thomas Y. Crowell Co., New York, 1964. 214 p. (Revised enlarged and brought up to date by R. S. Dodson) A

Freeman, Mae and Freeman, Ira: *The Sun, the Moon, and the Stars.* Random House Inc., New York, 1959. 83 p. P

George, Frances: *You and Space.* National Aerospace Education Council, Washington, D.C., 1962. 32 p. P

Gregor, Arthur C.: *A Short History of the Universe. The Stars and Planets, Their Birth, Evolution, Nature.* Macmillan Co., New York, 1964. 127 p. P, I

Hynek, J. Allen and Anderson, Norman D.: *Challenge of the Universe.* Scholastic Book Services, New York, 1962. 143 p. (Vistas of Science) A

Johnson, Gaylord: *The Story of Planets, Space, Stars.* Harvey House, Inc., Pub., Irvington-on-Hudson, New York, 1959. 153 p. P

Lapaz, Jean and Lapaz, Lincoln.: *Space Nomads: Meteorites in Sky, Field, and Laboratory.* Holiday House, New York, 1961. 187 p. I

Lyon, Jene: *Our Sun and the Worlds around It: Planets, Moon, Comets, and Other Wonders of the Solar System.* Golden Press, Inc., New York, 1961. 64 p. P

Munch, Theodore W.: *What Is a Solar System?* Benefic Press, Chicago, 1959. 41 p. I

National Aeronautics and Space Administration: *A Report from Mariner IV.* National Aeronautics and Space Administration, Washington, D.C., 1966. 8 p. (NASA FACTS, Vol. III, No. 3) I, U

National Aeronautics and Space Administration: *Mariner II Reports.* National Aeronautics and Space Administration, Washington, D.C., 1963. 8 p. (NASA FACTS, NFB-4-63) U

National Aeronautics and Space Administration: *Orbiting Solar Observatory.* National Aeronautics and Space Administration, Washington, D.C., 1966. 8 p. (Vol. III, No. 7) U

National Aeronautics and Space Administration: *Report from Mars.* National Aeronautics and Space Administration, Washington, D.C., 1966. 48 p. (EP-39) I, U, A

Parker, Bertha M.: *The Sun and Its Family.* Row Peterson, Evanston, Ill., 1959. 35 p. I, U

Pickering, James S.: *Captives of the Sun.* Dodd, Mead and Co., New York, 1961. 326 p. A

Polgreen, John and Polgreen, Cathleen: *The Earth in Space.* Random House, Inc., New York, 1963. 80 p. P

Ronan, Colin: *The Astronomers.* Hill and Wang, New York, 1964. 232 p. A
Shapp, Martha: *Let's Find out about the Sun.* Franklin Watts, New York, 1965. 47 p. P
Stern, Phillip D.: *Our Space Environment.* Holt, Rinehart, and Winston, New York, 1966. 153 p. I, U, A
Sullivan, Navin: *Pioneer Astronomers.* Atheneum Publishers, New York, 1964. 156 p. I
Tannenbaum, Harold and Stillman, Nathan: *We Read about Earth and Space.* McGraw-Hill Book Co., Inc., New York, 1960. 24 p. P
Thayer, Jane: *The Pussy Who Went to the Moon.* William Morrow and Co., New York, 1960. 32 p. P
Whipple, Fred L.: *Earth, Moon, and Planets.* Harvard University Press, Cambridge, Mass., 1963 (rev.) 278 p. A

AUDIO-VISUAL MATERIALS

NOTE: *These audio-visual materials are described as follows: "fr" for frame, "si" for silent, "b-w" for black and white, "sd" for sound, and "min." for minutes. The grade level suitability is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B contains the address of each of the distributors.*

The Astronomer at Work. McGraw-Hill Text Films. New York, 1959. 40 fr. si. color. U
Beyond our Solar System. Coronet Films, Chicago, 1959. sd. 11 min. b-w. P, I, U
Clouds of Venus. National Aeronautics and Space Administration, 1963. 30 min. sd. color. U, A
The Earth and the Sun. Eye Gate House, Jamaica, New York, 1959. 29 fr. si. color. P
The Earth is Born. Life Filmstrip, New York, 1953. 71 fr. si. color. U, A
Finding Out about the Universe. Society for Visual Education, Chicago, 1963. 42 fr. si. color. I
Interesting Things about the Planets. Jam Handy Organization, Detroit, 1947. 62 fr. si. b-w. I, U
Life on Other Planets. Eye Gate House, Jamaica, New York, 1956. 31 fr. si. color. I, U
Log of Mariner IV. National Aeronautics and Space Administration, 1966. 27 min. sd. color. I, U, A
Orbiting Solar Observatory National Aeronautics and Space Administration, 1962. 26 min. sd. color. U, A
Our Earth Is Part of the Solar System. Eye Gate House, Jamaica, New York, 1959. 41 fr. si. color. P, I
Our Solar System. Filmstrip House, New York, 1959. 29 fr. si. color. P
Planets Around Our Sun. United World Films, New York, 1961. 13½ min. sd. color. P, I, U
Solar System. Eye Gate House, Jamaica, New York, 1964. 43 fr. si. color. I, U
Sun and Its Family. Society for Visual Education, Chicago, 1957. 46 fr. si. color. I, U
Universe. National Film Board of Canada, 1960. 26 min. sd. b-w. (May be borrowed from NASA). I, U, A

VII. THE PLANETARIUM TEACHES ABOUT THE MOON

The United States plans to land its first astronaut team on the moon by 1970. This will fulfill a major goal in our space program. It will also help to fulfill man's age-old dream of discovering better explanations for some of the mysteries of the solar system.

The manned space flight program of our National Aeronautics and Space Administration is currently divided into three projects: Mercury, Gemini, and Apollo. Project Mercury has already been completed by using experimental one-man spacecraft to prove that men can be sent into space and be returned safely to earth. It has also yielded valuable scientific information. Project Gemini's two-man spacecraft was designed to achieve two major objectives: (1) extend orbital missions to several weeks at a time, and (2) develop and practice techniques for rendezvous and docking in space.

Project Apollo, biggest and most complex project of NASA's current manned space flight program, will produce a spacecraft composed of three modules: (1) the command module, in which a three-man astronaut team will be able to work, eat, and sleep without wearing pressure suits, (2) the service module which will contain fuel and rockets so that the pilots can propel their craft into and out of lunar orbit and change their course in space, and (3) the lunar excursion module, "LEM"* which will make the lunar landing.

Landing on the moon will require a series of complicated maneuvers by the Apollo crew. At blast-off the command module will ride atop the vehicle, with the service module and the LEM below, and will be placed in a parking orbit about the earth. Later, when the craft approaches moon orbit, the command and service modules will be separated from the LEM and will be rotated into a tail-forward position. The command module with the service module attached to one end and the LEM to the other, will continue toward the moon and into lunar orbit. At this point airlocks within the command module will be opened and two members of the team will climb into the LEM. The latter will then be detached for its descent to the moon.

After the moon excursion is completed, the lower part of the LEM will serve as a launching pad for the upper part, which will take off and rendezvous with the parent craft, the Apollo's command and service modules. The third member of the crew, in the meantime, will have been piloting this combined unit through a lunar orbit. The "explorers" will then transfer back to the parent craft, the LEM will be jettisoned, and the Apollo will head back to earth. The service module will be jettisoned during the journey back to earth.

But what do we know about the moon right now? We know that the moon is earth's natural satellite and revolves about earth in the direction, relative to the stars, west to east every 27 days, 7 hours, 43 minutes.

It accompanies earth on its annual revolution about the sun. The average distance between the center of the earth and the center of the moon is 239,000 miles. The moon has a diameter of 2,160 miles and a circumference of 6,800 miles. Its area is only about 1/14th that of earth. Because its periods of revolution and rotation are the same, we can only see one side.

We are not certain of much more. Scientists disagree on answers to many other tantalizing questions concerning the moon. For instance, what is its composition? How did it originate? Does life exist there?

*NASA officially changed the designation of "LEM," Lunar Excursion Module, to "LM," Lunar Module, in June, 1966

Learning about the moon has enabled man to learn about the earth. Observations of lunar eclipses in the fourth century B.C., for instance, supplied the first evidence that the earth was round. Future learning about the moon will offer even more exciting data about the earth and about the entire solar system.

THE BRIDGEPORT PLANETARIUM VISIT, 1963-64

A Brief Account of the Class Experience

Through the magic of the planetarium, the young audience is taken a few hundred miles above the surface of the North Pole. From this vantage point, they can see the sun near the horizon. While the moon is there, too, it cannot be seen. The reason it cannot be seen while it is there, the lecturer explains, is that the moon reflects the sun's light and, at this stage in its orbit around the earth, it has moved between the sun and the earth. The side turned toward the earth, therefore, is completely dark. This phase is the new moon. What are termed the moon's phases result from the changing amounts of its sunlit surface that are visible from earth. The lecturer then "condenses" time so that the children can follow the moon on its entire journey around the earth and watch its various phases.

The scene changes, and the children find themselves inside a giant lunar vehicle. After a warning to fasten imaginary seatbelts or hold tight to their chairs because of the hazards of thrust and G forces, a buzzer is sounded and the countdown begins. With a great roar the lunar vehicle lifts off its pad and gradually gains speed to streak away toward the moon.

The lecturer explains that the lunar vehicle will land on the daylight side of the moon, inside a great crater. The pilot's voice breaks in to announce that the braking rockets are about to be fired. Above the engine roar that follows, the lecturer explains that the craft has been turned about so that it will be able to make a soft landing. Then, with a brilliant flash, a landing is made on the moon and the children are surrounded on all sides by the walls of a crater. To protect them from the radiation that sweeps the moon's surface because of lack of atmosphere, passengers view their surroundings through a transparent shield. Overhead, a black sky holds brilliant stars, the planets, the sun, and a great, blue, crescent-shaped object which is identified as the planet earth. The lecturer explains how, because of the lack of atmosphere, the sky seen from the moon is black both day and night. Because of this, the stars and the sun are visible at the same time. There is no sound, no odor, no clouds, no sunset or sunrise glow, and no weather. From the moon's surface, the observer can see all the constellations visible at that point stream by in a month, while on the earth's surface it would take a year.

The lecturer points out a reddish line that encircles the earth where the day meets the night. This is sunset glow, a complete horizon all the way around the earth that produces a "continuous" sunset. As the audience watches, the sun apparently sets and in an instant the lunar features disappear. The lecturer explains to his audience that there is no atmosphere and no color in the sky, and the temperature outside their vehicle will drop from 250 degrees above zero to 250 degrees below zero in an hour's time. This results in sudden and extreme expansion and contraction of the surface of the moon.

The lecturer and his audience join in identifying and reviewing the stars and constellations. Then, a warning horn is sounded and once again the children find themselves in the lunar vehicle taking off for their journey back to earth.

PIONEERS IN SPACE SCIENCE

Dryden	(1898–1965 A.D.)	Newell	(1915– A.D.)
Gagarin	(1934– A.D.)	Oberth	(1894– A.D.)
Gilruth	(1913– A.D.)	Pickering	(1910– A.D.)
Glenn	(1921– A.D.)	Tsiolkovsky	(1857–1935 A.D.)
Goddard	(1882–1945 A.D.)	Van Allen	(1914– A.D.)
Von Braun	(1912– A.D.)		

VOCABULARY

airlock crater g force jettison LEM lunar eclipse lunar orbit module new moon radiation sunset glow

SOME QUESTIONS CONCERNING THE MOON

1. Is the atmosphere on the moon like ours?
2. Is the moon likely to support life?
3. How would you describe the "sounds of space"?
4. What is it like on the surface of the moon?
5. Why doesn't the moon fall to the earth or whirl away into space?
6. Why does the moon change phases?
7. What is the difference between the daytime and the nighttime temperatures of the moon?
8. From a viewpoint on the moon, why does the earth seem to stand still and the stars and planets seem to move?
9. How does a rocket work?
10. Would wings help a spacecraft?
11. What would you take with you on a trip to the moon?
12. How would space travelers communicate on the moon?
13. What instruments might be used in space navigation?
14. What would you like to bring back from the moon?
15. What size crew will be used for the first Apollo trip to the moon?
16. How long does it take radio signals to reach the earth from a spacecraft on the moon?

SUGGESTED PUPIL ACTIVITIES

PRIMARY

1. Cut out and bring in pictures of spacecraft.
2. Discuss the things we need for life on earth. Does the moon have these things?
3. Look at pictures of the moon. What different shapes and formations do you see? What do they suggest?
4. Using pupils in class, dramatize the moon's revolution around the earth.
5. Draw pictures showing the various phases of the moon.
6. Find out what kinds of food space explorers will bring with them.
7. Look at pictures of the Saturn 5 with the Apollo spacecraft on top. What different sections do you see? Discuss the different sections in class.

INTERMEDIATE

1. Make up an original story or poem about space-flight experiences.
2. Dramatize various portions of the Apollo moon trip.
3. Find out what causes the phases of the moon.
4. Make a list of questions that must b answered before we can tell whether life exists on the moon.
5. Find out about the Mercury program and the nature of its various missions.
6. Find out how the Gemini program differs from the Mercury program.
7. Find out how the Apollo program differs from the Gemini program.
8. Using pupils in class, dramatize solar and lunar eclipses.
9. Find out when the next lunar eclipse will occur.
10. Diagram a launch vehicle, labeling the major components.

UPPER

1. Make a "space exploration log" in which you indicate (a) name of mission, (b) date, (c) purpose of mission, (d) type of launch vehicle, (e) type of spacecraft, (f) number of orbits, and (g) resultant information.
2. Draw pictures of the Apollo space flight to and from the moon. Indicate what happens to the command module, the service module, and the LEM during the trip.
3. Organize the class into groups to prepare for an imaginary trip to the moon. What would they take with them? What resources are they likely to find on the moon? What would life be like on the moon? What would they see there?
4. Write a descriptive statement about the moon including its diameter, distances, mass compared to the earth's mass, surface gravity, surface features, and motions.
5. Use the chalkboard to illustrate the librations of the moon.
6. Read to find out about various theories concerning the origin of the moon.
7. Find out how lunar eclipses can be predicted so accurately.
8. Report on the knowledge about the moon as explained in books published prior to 1964, as compared with what is now known.

BIBLIOGRAPHY

NOTE: *The grade level suitability of these materials is indicated by letters following each listing: "P" for primary, "I" for intermediate, "U" for upper, and "A" for adult. Appendix B includes the address of each of the publishers.*

Bendick, Jeanne: *The First Book of Space Travel.* Franklin Watts, New York, 1963. 68 p. P, I

Bergaust, Erik: *Rockets to the Moon.* G. P. Putnam's Sons, News York, 1961. 48 p. U.

Branley, Franklyn M.: *What the Moon Is Like.* Thomas Y. Crowell, New York, 1963. 40 p. P

Brenna, Virgilio: *The Moon.* Golden Press, New York, 1963. 108 p. U

Daugherty, Charles M.: *Robert Goddard.* Macmillan, New York, 1964. 48 p. I

Dewey, Ann Perkins: *Robert Goddard, Space Pioneer.* Little Brown & Co., Boston, 1962. 154 p. I, U

Dille, John: *Americans in Space.* Harper and Row, New York, 1965. 155 p. I, U

Emme, Eugene M.: *A History of Space Flight.* Holt, Rinehart and Winston, New York, 1965. 192 p. A

Emme, Eugene M.: *Historical Sketch of NASA.* National Acronautics and Space Administration, Washington, D.C., 1965. 56 p. (EP-29) A

Fenton, Carroll Lane: *The Moon for Young Explorers.* John Day Co., New York, 1963. 64 p. P, I

Freeman, Mae and Freeman, Ira: *You Will Go to the Moon and the Stars.* Random House, New York, 1959. (pages not listed) P

Haggerty, James J., Jr.: *Man's Conquest of Space.* Scholastic Book Services, Englewood Cliffs, New Jersey, 1966. 125 p. (Vistas of Science) U, A

Lent, Henry: *Man Alive in Outer Space, Our Space Surgeon's Greatest Challenge.* Macmillan, New York, 1961. 147 p. I

Ley, Willy: *Missiles, Moonprobes and Megaparsecs.* Signet, New York, 1964. 189 p. A

Moffatt, Samuel and Shneour, Elie A.: *Life Beyond the Earth.* Scholastic Book Services, Englewood Cliffs, New Jersey, 1965. 156 p. (Vistas of Science) U, A

Myrus, Don: *The Astronauts.* Grosset and Dunlap, Inc., New York, 1963. 93 p. I, U

National Aeronautics and Space Administration: *Launch Vehicles.* National Aeronautics and Space Administration, Washington, D. C., 1964. 8 p. (NASA FACTS, Vol. II, No. 5) Color Supplement. (NASA FACTS, Vol. II, No. 5 Suppl.) I, U

National Aeronautics and Space Administration: *Manned Space Flight, Project Apollo.* National Aeronautics and Space Administration, Washington, D. C., 1965. 12 p. (NASA FACTS, Vol. III, No. 1) I, U

National Aeronautics and Space Administration: *Manned Space Flight, Projects Mercury and Gemini.* National Aeronautics and Space Administration, Washington, D. C., 1965. 12 p. (NASA FACTS, Vol. II, No. 8) I, U

National Aeronautics and Space Administration: *Project Ranger.* National Aeronautics and Space Administration, Washington, D. C., 1965. 12 p. (NASA FACTS, Vol. III, No. 2) I, U

National Aeronautics and Space Administration: *Space, the New Frontier.* National Aeronautics and Space Administration, Washington, D. C., 1966. 96 p. (EP-6 Rev.) I, U

National Aeronautics and Space Administration: *The View from Ranger.* National Aeronautics and Space Administration, Washington, D. C., 1966. 58 p. (EP-38) I, U, A

Newell, Homer E.: *Guide to Rockets, Missiles, and Satellites.* McGraw-Hill Book Co., New York, 1961. 96 p. I, U

Newlon, Clarke: *Famous Pioneers in Space.* Dodd, Mead and Co., New York, 1963. 127 p. I, U

Page, Thornton and Page, Lou Williams, Eds.: *Wanderers in the Sky.* Macmillan, New York, 1965. 338 p. A

Ruzic, Neil P.: *The Case for Going to the Moon.* G. P. Putnam's Sons, New York, 1965. 240 p. A

Sadil, Josef: *The Moon and the Planets.* Paul Hamlyn, New York, 1963. 184 p. I

Shapp, Martha: *Let's Find Out About the Moon.* Franklin Watts, New York, 1965. 55 p. P

Stern, Phillip D.: *Our Space Environment.* Holt, Rinehart, and Winston, New York, 1966. 153 p. I, U

Thomas, Shirley: *Men of Space.* Chilton Books, Philadelphia, a continuing series of seven volumes, beginning in 1960. U

Verral, Charles S.: *Robert Goddard, Father of the Space Age.* Prentice Hall, New York, 1963. 80 p. I

Von Braun, Wernher: *First Men to the Moon.* Holt, Rinehart, and Winston, New York, 1960. I, U

Voris, Frank B.: *Medical Aspects of Space Flight.* National Aeronautics and Space Administration, Washington, D. C., 1964. 76 p. (EP-17) A

Wells, Robert: *Alive in Space, The Science of Bio-Astronautics.* Little, Brown and Company, Boston, 1961. 180 p. I

Whipple, Fred L.: *Earth, Moon, and Planets.* Harvard University Press, Cambridge, Massachusetts, 1963 (rev.) 278 p. A

AUDIO-VISUAL MATERIALS

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Celestial Mechanics and the Lunar Probe. National Aeronautics and Space Administration, 1958. 9½ min. sd. color. U, A

The Changing Moon. Jam Handy Organization, Detroit, 1947. 69 fr. si. b-w. I, U

The Dream That Wouldn't Down. National Aeronautics and Space Administration, 1965. 27 min. sd. b-w I, U, A

Exploring the Moon. Encyclopedia Britannica Films, Wilmette, Illinois, 1961. 33 fr.

The Four Days of Gemini IV. National Aeronautics and Space Administration, 1965. 28 min. sd. color. P, I, U, A

Friendship 7. National Aeronautics and Space Administration, 1962. 59 min. sd. color. I, U, A

Lunar Bridgehead. National Aeronautics and Space Administration, 1964. 29 min. sd. b-w. I, U, A

Man and the Moon. Encyclopedia Britannica Films, Wilmette, Illinois, 1959. 49 fr. si. color. I, U

Mastery of Space. National Aeronautics and Space Administration, 1962. 58 min. sd. color. I, U, A

The Moon. Cenco Educational Films, Chicago, 1963. 14 min. sd. color. P, I, U

The Moon–Our Nearest Neighbor. Filmstrip-of-the-Month Club, New York, 1962. 42 fr. si. color. I, U

The Moon. Encyclopedia Britannica Films, Wilmette, Illinois, 1956. 48 fr. si. color. I, U

The NASA Bio-Satellite Program (Between the Atom and the Star). National Aeronautics and Space Administration, 1965. 28 min. sd. color. I, U, A

Project Apollo-Manned Flight to the Moon. National Aeronautics and Space Administration, 1963. 13 min. sd. color. I, U, A

Ranger VII Photographs of the Moon. National Aeronautics and Space Administration, 1964. 7 min. sd. b-w. I, U, A

Ranger VIII Photographs of the Moon. National Aeronautics and Space Administration, 1965. 7½ min. sd. b-w. I, U, A

Ranger IX Photographs of the Moon. National Aeronautics and Space Administration, 1965. 6½ min. sd. b-w. I, U, A

Rocket Power for Space Travel. Jam Handy Organization, Detroit, 1960. 40 fr. si. color. I, U

APPENDIX A

GLOSSARY

This glossary is intended for use with elementary-school age children. The definitions are designed to provide the children with easily understandable concepts that may serve as a base for further study.

absorption—the taking up of one substance by another. When radiant energy is absorbed, it is converted into another form of energy.

abstraction—a general idea that is used without reference to particular objects or situations.

aesthetics—ideas concerning beauty developed by the mind and emotions.

airlock—a chamber used to adapt individuals to changes in pressure.

apogee—the point in an object's orbit when the object is farthest from its main source of gravity.

atmosphere—a mass of gas or gases that surrounds the earth or other celestial body.

atomic reactor—a device in which a chain reaction occurs as the result of nuclear fission or the splitting of atomic nuclei.

aurora—a display of moving, colored lights in the night sky, probably caused by solar energy striking gas particles above earth.

auxiliary earth—a model or substitute device that aids understanding where the earth is involved in a particular study.

axiom—a universally accepted principle or rule.

calendar—any one of several systems for reckoning time in terms of the earth's annual journey around the sun.

cloud seeding—the discharge of materials into clouds for the purpose of inducing or preventing rain.

comet—a heavenly body moving in the solar system; consists of a bright, luminous head and a long tail.

constellation—a group of stars that may be said to form a picture or design in the sky.

contrail—the visible stream of gases emitted by a rocket or jet airplane.

cooling jacket—a device that serves to lower the temperature of a rocket engine or other engine. It is usually filled with fluid that absorbs the heat of the engine, which it surrounds.

crater—a cupped pit on the surface of the earth or other celestial body.

data—information, set of facts, evidence.

deductive logic—reasoning from a general principle to a specific application of the principle.

doldrums—a belt surrounding the earth near the equator, noted for high humidity and little wind.

dormant—inactive

eclipse—the temporary darkening of a celestial body caused when some other object comes between that object and an observer.

elliptical orbit—the shape of a planet's orbit; a somewhat flattened circle.

evidence—information, set of facts, data.

fixed stars—stars that appear not to move with reference to other stars.

fluoroscope—a tube or box used for viewing objects exposed to x-rays or other radiation.

functional concept—an idea that may be seen or practiced in everyday life.

geology—the study of the history, composition, and structure of the earth.

geometric form—any one of several forms consistent with the branch of mathematics called geometry; circles, squares, triangles are such forms.

g forces—forces of gravity exerted on an object; the earth's gravity is equal to one g.

gravitational field—a region in which an object or mass is subjected to gravitational force.

gravitation—the force that attracts all bodies in the universe to one another.

gravity—the force that attracts objects to the center of the earth, or other primary body in space.

hemisphere—half of a sphere; either of two halves of the earth formed by an imaginary plane passing through its center.

horizon—the boundary between the earth's surface and the sky.

hypothesis—an unproved statement made for the purpose of experimentation.

inductive logic—reasoning from a set of particulars to a general principle or rule.

inertia—resistance to motion when at rest, or to change in motion or direction when moving.

infrared—the invisible rays of the electromagnetic spectrum that have a wavelength slightly longer than those of the visible color red but shorter than those of radio waves.

International Date Line—an imaginary line in the Pacific Ocean, roughly around the 180th meridian, at which time changes forward or backward 24 hours.

jettison—to drop materials from a ship or craft in motion in order to reduce its load.

LEM—Lunar Excursion Module, the craft that the U. S. A. will use to explore the surface of the moon.

light intensity—the degree of brightness or illumination.

light meter—a device that measures the intensity of light.

lunar eclipse—an eclipse of the moon caused by the earth's shadow darkening the moon.

lunar orbit—an orbit around the moon.

mathematical application—the application of mathematical abstractions to a practical problem or situation.

Mars—the fourth planet from the sun, the third smallest in size, and the nearest to earth; appears as a red star.

meteoroid—a very small, solid body that is traveling through space.

meteorologist—a scientist who studies weather.

method—a plan, a systematic procedure, a way of doing something.

module—an interchangeable unit of design or construction, a section.

myth—an invented, legendary story.

nebula—a cloud-like mass of dust and gas in interstellar space.

new moon—that phase of the moon when it receives the light of the sun on the side facing away from earth.

orbit—the path any object follows as it revolves around any other object such as a planet's orbit around the sun or a satellite's orbit around the earth.

perigee—the point in an object's orbit when the object is closest to its main source of gravity.

phase—any one of the changing stages in the apparent illumination of the moon or planets.

phenomenon—a fact or occurrence of scientific interest.

planet—any one of the nine largest opaque bodies revolving around the sun. From the Greek word meaning wanderer.

prediction—a forecast of coming events based on the scientific interpretation of observations.

prime meridian—the meridian indicated as 0 degrees which separates the regions of east and west longitude; passes through Greenwich, England.

prism—a wedge-shaped piece of material, usually glass, through which light passes and is refracted into the colors of the spectrum.

propellant—Material used to move or propel an object, especially a missile or space vehicle.

radiation—the process by which energy is emitted and transmitted in the form of waves.

revolve—to move in one complete orbit; usually refers to a celestial body's elliptical orbit around another.

rotate—to spin around on an axis.

satellite—any object or body that revolves around a larger one.

seasons—the four periods into which the earth's year is divided; spring, summer, winter, fall.

sextant—an instrument used to measure the angle of the stars appearing above the horizon.

solar batteries—devices used to change the radiant energy of the sun into electrical energy.

spectrograph—an instrument that separates light radiation into a spectrum and records it on a photographic plate.

spectrum—the color bands produced when white light is passed through a prism or diffraction grating; also, a separation by wavelength.

sun dog—a small or incomplete rainbow.

sunset glow—the lighting of the surface of the earth after the sun has set, caused by the reflection and refraction of sunlight by the atmosphere.

Sputnik—the first man-made satellite put in orbit around the earth.

supernatural—pertaining to something beyond the natural; extraordinary.

telemetry—the recording and transmission of information taken by a distant object, such as a satellite.

thrust—the force that pushes an aircraft or spacecraft.

time zones—the twenty-four divisions on the earth, calculated from the solar time of Greenwich, England, to compensate for the earth's rotation.

variable—a symbol that may represent any one of several objects or occurrences.

velocity—the speed and direction of a moving object.

visible spectrum—those wavelengths of electromagnetic radiation that can be seen by man.

wandering stars—a term used by some ancient people referring to planets.

wavelengths—the distances between successive waves, usually measured from crest to crest.

weather satellite—a man-made satellite used to study the earth's weather conditions.

weightlessness—"Apparent" weightlessness occurs during the free fall of a space vehicle in orbit.

year—the time it takes for the earth to make one complete revolution around the sun.

APPENDIX B

NAMES AND ADDRESSES OF SOURCES FOR BOOKS AND AUDIO-VISUAL MATERIALS LISTED AT END OF EACH CHAPTER

Abelard-Schuman, Ltd., 6 West 57th St., New York 19, New York, 10019
Adler Planetarium and Astronomical Museum, 900 East Achsah Bond Dr., Chicago, Illinois, 60605
Aerojet General Corporation, Public Relations Department, P. O. Box 3925, Glendale, California, 91201
Aerospace Industries Association of America, Inc., 1725 DeSales Street, N.W., Washington, D.C., 20036
Air Transport Association of America, 1000 Connecticut Ave. N.W., Washington, D.C., 20036
Aldine Publishing Co., 64 E. Van Buren St., Chicago, Illinois, 60605
American Meteorological Society, 45 Beacon Street, Boston, Massachusetts, 02108
American Museum-Hayden Planetarium, Department of Education, 81st Street, and Central Park West, New York, New York, 10024
Atheneum Publishers, 162 East 38th Street, New York, New York, 10016
Association Films, 347 Madison Avenue, New York, 10017
Atlantis Productions, Inc., 1505 N. Gardner Street, Hollywood, California, 90046
Bailey Films, Inc., 6509 Delongpre Avenue, Hollywood, California, 90028
Bell Telephone Company (Make request at local Bell Telephone Company Office)
Benefic Press, The Beckley Cardi Company, 1900 N. Narragansett, Chicago, Illinois, 60639
Charles Besler Co., 219 South 18th Street, East Orange, New Jersey, 07018
Birad Corporation, 1564 Broadway, New York, New York, 10036
Boeing Co., The Public Relations Dept., 3801 So. Oliver, Wichita, Kansas, 67210
Cadillac Publishing Co., 220 5th Avenue, New York, New York, 10010
Careers, P. O. Box 135, Largo, Florida, 33541
Cenco Educational Films, 1700 West Irving Park Rd., Chicago, Illinois, 60613
Cessna Aircraft Company, P. O. Box 1521, Wichita, Kansas, 67201
Children's Press, Inc., 1224 W. Van Buren St., Chicago, Illinois, 60607
Chilton Books, Trade Book Division, 227 South 6th Street, Philadelphia, Penna., 19106
Civil Air Patrol, National Headquarters, Ellington Air Force Base, Texas, 77030
Communicative Arts, P. O. Box 11617, San Diego, California, 92111
F. E. Compton Co., 1000 North Dearborn Street, Chicago, Illinois, 60610
Coronet Instructional Films, Coronet Building, 65 East South Water Street, Chicago, Illinois, 60601
Coward-McCann, Inc., 200 Madison Avenue, New York, New York, 10016
George F. Cram Co., 730 E. Washington St., Indianapolis, Indiana, 46202
Creativision, Inc., 1780 Broadway, New York, New York, 10019
Thomas Y. Crowell Co., 201 Park Avenue South, New York, New York, 10003
Curriculum Materials Corp., 1319 Vine Street, Philadelphia, Pennsylvania, 19107
John Day Co., Inc., 200 Madison Avenue, New York, New York, 10016
Denoyer-Geppert Co., 5235 Ravenswood Avenue, Chicago, Illinois, 60640
Walt Disney Films, 350 So. Buena Vista St., Burbank, California, 91503
Dodd-Mead and Company, 432 Park Avenue South, New York, New York, 10016
Doubleday & Co., Inc., 501 Franklin Avenue, Garden City, New York, 11530

Dover Publications, 180 Varick Street, New York, New York, 10014
Duell, Sloan & Pierce, Inc. (See Meredith Press)
E. P. Dutton and Company, Inc., 201 Park Avenue So., New York, New York, 10003
Educational Audio Visual, Inc., 29 Marble Avenue, Pleasantville, New York, 10570
Encyclopedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Illinois, 60091
Esso Research and Engineering Co., Public Relations Dept., P. O. Box 45, Linden, New Jersey, 07036
Eye Gate House, Inc., 146-01 Archer Avenue, Jamaica, New York, 11435
Fawcett Publications, Inc., Fawcett Place, Greenwich, Connecticut 06830
Federal Aviation Agency, Film Library, AC-142.1 Aeronautical Center, P. O. Box 1082, Oklahoma City, Oklahoma, 73101
Field Enterprises, Educational Corporation, Merchandise Mart Plaza, Chicago, Illinois, 60654
Film Associates of California, 11014 Santa Monica Blvd., Los Angeles, California, 90025
Filmstrip House, 432 Park Avenue So., New York, New York, 10016
Filmstrip-of-the-Month Club, Inc., 355 Lexington Avenue, New York, New York, 10017
The William Frederick Press, 55 East 86th Street, New York, New York, 10028
W. H. Freeman and Company, 660 Market Street, San Francisco, California, 94104
Garden City Book Club (See Doubleday)
Garrard Publishing Co., 862 Scarsdale Avenue, Scarsdale, New York, 10583
General Aniline and Film Corp., Photo and Reproduction, Binghamton, New York, 13902
Golden Press, Inc., 850 3rd Avenue, New York, New York, 10022
Griffith Observatory and Planetarium, P. O. Box 27787, Griffith Park, Los Angeles, California, 90027
Grosset and Dunlap, Inc., 51 Madison Avenue, New York, New York, 10010
Grumman Aircraft Engineering Corporation, c/o Public Relations, Bethpage, New York, 11714
Hafner Publications, Inc., 81 E. 10th St., New York, New York, 10003
Paul Hamlyn (See Tudor Publishing Co.)
Harcourt, Brace and World, Inc., 757 Third Avenue, New York, New York, 10017
Harper and Row Publishers, Inc., 49 East 33rd Street, New York, New York, 10016
Harvard University Press, 79 Garden Street, Cambridge, Massachusetts, 02138
Harvey House, Inc., Publishing, Irvington-on-Hudson, New York, 10533
Hill and Wang, 141 Fifth Avenue, New York, New York, 10010
Holiday House, Inc., 8 W. 13th Street, New York, New York, 10011
Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York, New York, 10017
Houghton Mifflin Co., 2 Park Street, Boston, Massachusetts, 02107
Hubbard Scientific Co., Box 105, Northbrook, Illinois, 60062
Instructo Products Co., 1635 N. 55 Street, Philadelphia, Pennsylvania, 19121
International Film Bureau, 322 South Michigan Avenue, Chicago, Illinois, 60604
International Screen Organization, 1445 18th Avenue, No. St. Petersburg, Florida, 33704
Jam Handy Organization, 2821 East Grand Blvd., Detroit, Michigan, 48211
Alfred A. Knopf, Inc., 501 Madison Avenue, New York, New York, 10022
J. B. Lippincott and Co., East Washington Square, Philadelphia, Pennsylvania, 19105
Little, Brown and Co., 34 Beacon Street, Boston, Massachusetts, 02106
Lothrop, Lee and Shepard Co., 419 Park Avenue So., New York, New York, 10022
McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York, New York, 10036
The Macmillan Co., 60 Fifth Avenue, New York, 10011
Markhart Educational Services, Preston, Idaho, 83263

Meredith Press, 1716 Locust Street, Des Moines, Iowa, 50303
Charles E. Merrill Books, Inc., 1300 Alum Creek Drive, Columbus, Ohio, 43216
Moody Institute of Science, Educational Division, 11428 Santa Monica Blvd., Los Angeles, California, 90025
Morehead Planetarium, University of North Carolina, Chapel Hill, North Carolina, 27515
William Morrow and Co., Inc., 425 Park Avenue South, New York, New York, 10016
National Aeronautics and Space Administration (See Appendix C for the National Aeronautics and Space Administration field installation which serves your state)
National Aerospace Education Council, Room #616, Shoreham Bldg., 806 15th Street, N.W., Washington, D.C., 20005
National Council of Teachers of Mathematics, NEA, 1201 16th Street, N.W., Washington, D.C., 20036
National Geographic Society, Publication Order Dept., 1145 17th Street, N. W., Washington, D. C., 20036
National Instructional Television Library, 10 Columbus Circle, New York, New York, 10019
New York Times, Office of Educational Activities, 229 West 43rd St., New York, New York, 10036
Noble and Noble, Publishers, Inc., 67 Irving Place, New York, New York, 10003
Norwood Studios, 926 New Jersey Avenue N. W., Washington, D. C., 20011
Number Films, 17350 Gresham St., Northridge, California, 91324
Pelican Books, Penguin Books, Inc., 3300 Clipper Mill Rd., Baltimore, Maryland, 21211
Pergamon Press (See Macmillan)
Portafilms, Orchard Lake, Michigan, 48034
Public Affairs Pamphlets, 22 East 38th Street, New York, New York, 10016
G. P. Putnam's Sons, 200 Madison Avenue, New York, New York, 10016
Rand McNally and Company, P. O. Box 7600, Chicago, Illinois, 60680
Random House, Inc., 457 Madison Avenue, New York, New York, 10022
Rohm and Hass Co., Attention: Redstone Arsenal Research Div., Huntsville, Alabama, 35801
Row-Peterson and Co. (See Harper and Row)
Scholastic Book Services, 904 Sylvan Avenue, Englewood Cliffs, New Jersey, 07632
Science Clubs of America, Science Service, 1719 N. Street N.W., Washington, D. C., 20036
Charles Scribner's Sons, 597 Fifth Avenue, New York, New York, 10017
Dr. Jay Shuler, 43 Kirkwood Lane, Greenville, South Carolina, 29607
Signet Science Library (The New American Library of World Literature, Inc.,) 501 Madison Avenue, New York, 10022
Sikorsky Aircraft, Public Relations Department, North Main Street, Stratford, Connecticut, 06497
Simon & Schuster, Inc., 1 West 39th Street, New York, New York, 10018
L. W. Singer Co. (See Random House)
Sky Publishing Corp., 49 Bay Station Road, Cambridge, Massachusetts, 02138
The Smithsonian Institution, Publications Distribution Section, Washington, D. C., 20560
Society for Visual Education, 1345 Diversey Pkwy., Chicago, Illinois, 60614
Sterling Publishing Co., Inc., 419 Fourth Avenue, New York, New York, 10016
Teachers Publishing Corp., 23 Leroy Avenue, Darien, Connecticut, 06820
Time and Life, Inc., 9 Rockefeller Plaza, New York, New York, 10020

2.

Travelers Insurance Company, Hartford, Connecticut, 06101
Tudor Publishing Co., 221 Park Avenue South, New York, New York, 10003
United Air Lines, School and College Services, P. O. Box 8800, Chicago, Illinois, 60666
United Illuminating Company, 1115 Broad St., Bridgeport, Connecticut, 06603
U.S. Coast and Geodetic Survey, Public Information Staff, Washington Science Center, Rockville, Maryland, 20852
U.S. Government Printing Office, Superintendent of Documents, Washington, D.C., 20402
U.S. Weather Bureau. Write Public Information Office, Environmental Science Services Administration, Washington Science Center, Rockville, Maryland, 20852
United World Films, Inc., 221 Park Avenue South, New York, New York, 10003
University of Illinois, Audio-Visual Center, Division of University Ext., Champaign, Illinois, 61822
University of North Carolina, Bureau of Audio-Visual Education, 111 Abernethy Hall, Chapel Hill, North Carolnia, 27515
D. Van Nostrand Co., Inc., 120 Alexander Street, Princeton, New Jersey, 08540
Viking Press, Inc., 625 Madison Avenue, New York, New York, 10022
Vintage Books (See Random House)
Washington Square Press, Inc., Attn: Affiliated Publishers, Inc., 630 5th Avenue, New York, New York, 10020
Franklin Watts, Inc., 575 Lexington Avenue, New York, New York, 10022
Webster Publishing Co. (See McGraw-Hill Book Co., Inc.)
John Wiley and Sons, Inc., 605 3rd Avenue, New York, New York, 10016
World Publishing Co., 2231 W. 110 Street, Cleveland, Ohio, 44102
Yale University Press, 92 A Yale Station, New Haven, Connecticut, 06511
Young America Films, Inc. (See McGraw-Hill)

APPENDIX C

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Requests for NASA films, publications and services may be addressed to the offices listed below:

FIELD OFFICES	AREA SERVED
Educational Services Officer Public Affairs Office NASA Ames Research Center Moffett Field, California 94035	Alaska, Idaho, Montana, Northern California Oregon, Washington, Wyoming
Educational Programs Officer NASA Electronics Research Center 575 Technology Square Cambridge, Massachusetts 02139	Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont
Educational Liaison Branch Public Affairs Office NASA George C. Marshall Space Flight Center Huntsville, Alabama 35812	Alabama, Arkansas, Louisiana, Mississippi, Missouri, Tennessee
Educational Programs Officer Public Affairs Office NASA Goddard Space Flight Center Greenbelt, Maryland 20771	Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, West Virginia
Community Development Office NASA John F. Kennedy Space Center Cocoa Beach, Florida 32931	Florida, Georgia, Puerto Rico, Virgin Islands
Educational Programs and Services NASA Langley Research Center Langley Station Hampton, Virginia 23365	Kentucky, North Carolina, South Carolina, Virginia
Educational Services Office of Educational Programs NASA Lewis Research Center 21000 Brookpark Road Cleveland, Ohio 44135	Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, Wisconsin
Educational Programs and Services Public Affairs Office NASA Manned Spacecraft Center 2101 Webster-Seabrook Road Houston, Texas 77058	Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas
Educational Programs Division NASA Western Support Office 150 Pico Boulevard Santa Monica, California 90406	Arizona, Hawaii, Nevada, Southern California, Utah

HEADQUARTERS: Educational Programs Division, Code FE, National Aeronautics and Space Administration, Washington, D.C. 20546.

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